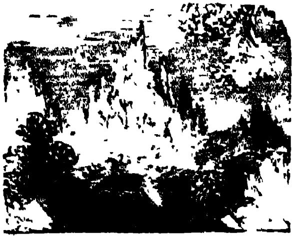
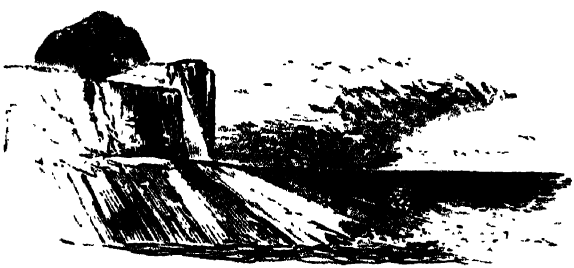
GEOLOGICAL SECTIONS



Indeterminate and Pointed Stratification.



Inclined Stratification

Vertical and Inclined Stratification.

SOILS AND MANURES

THE IMPROVEMENT OF LAND,

AND THE ROTATION OF CROPS.

BY JOHN DONALDSON,

GOVERNMENT LAND DRAINAGE SURVEYOR

VOLTZIA HETEROPHYLLA, AN EXTINCT SPECIES OF CONIFERA, FOUND NEAR STRASBURG.

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CHEMISTRY OF SOILS AND MANURES.

CHAPTER I.

GEOLOGICAL FORMATION OF SOILS.

AGRICULTURE has been concisely defined in two Latin words, "Arare et Stercorare," or in English, to "plough and manure;" a sufficiently correct definition certainly, but wholly depending on the modes and ways in which the two operations and processes are performed. The earth is the foundation on which the whole matter rests; which, understood largely, comprehends the whole terraqueous globe, but it is the upper stratum, called in an agricultural sense the "soil," that is used in cultivation. Theory is an enlightened interpretation of facts in their various relations,—a placing together in the mind, our most improved knowledge, from which the results may be deduced, but requiring the test of experience to prove its utility. Our theory of agriculture comes to this: if lands be wet, drain them; if foul, clean them; and if poor, manure them; if too heavy, ameliorate them with lighter soil; if too light, add clay to them.

In most of the theories that have been put forth by our "earth-making" writers, it has been assumed as a principle, that the agglutinated and hardened mineral masses which we see forming mountains, and to which we have given the name of rocks, originally formed the crust of the earth, whether produced by aqueous or igneous agency, or whether proceeding from a state of solution, or of fusion; and that all the other bodies and formations, massive, detached, or reduced in form and substance, have been produced from the decomposition of the original substances by the effect of convulsions, disruptions,

and of the universal deluge, to all which phenomena the earth has been subjected.

Geologists reckon five formations :—1. Primitive rocks; 2. Intermediate or Transition; 3. Secondary or Flœtz; 4. Alluvial; 5. Volcanic.

1. The first is called Primary or Primitive, from being supposed to form the original crust of the earth superficially, or to a moderate depth, and from containing no organic remains, as in the other formations. This latter circumstance marks the distinguishing character; and the primary stratification has accordingly had a period of formation assigned to it, antecedent to the creation of organic being. The class comprehends nine genera, with varieties and divisions :—1. Granite, with syenite and topaz; 2. Gneiss; 3. Micaceous schistus, with varieties of talc; 4. Argillaceous schistus, with alum and flinty slates; 5. Granular limestone and primitive gypsum; 6. Porphyry; 7. Trap; 8. Serpentine and asphotite; 9. Quartz. Primitive rocks are mostly upheaved in vast Alpine chains, having other rocks resting on their bases, they exhibit fixed relations with other strata, and follow a regular order of succession, as they support, but never rest upon or alternate with, or cover others; and they contain either occasionally or exclusively almost every metal yet discovered.

2. The second class, viz., Transition rocks, comprehends nine genera, and species :—1. Granite and porphyry; 2. Gneiss and mica slate; 3. Transition limestone; 4. Grauwacke; 5. Red sandstone; 6. Serpentine; 7. Quartz rock; 8. Gypsum; 9. Transition trap. These formations denote the passage between the perpendicular or primitive and the secondary or horizontal strata, and are called transition rocks because they show a passage or transition from one state of existence to another. In these rocks organic remains are not wholly wanting, but are not always found; and hence the distinction is not very clearly marked in many cases, whether they belong to the primary or to the secondary formation.

3. In the third division, or Flœtz formation, the principal rocks are sandstone, gypsum, limestone, trap, and porphyries, with many species and divisions. They are much less crystalline than primitive and transition rocks, and are particularly distinguished by the number, variety, and abundance of fossil organic species of animal and vegetable exuviæ which they contain imbedded in their substance.

The first genus, or Sandstone, comprehends the old red sandstone, with the coal formations, containing both animal and vegetable remains; the variegated sandstone; the quartzose sandstone, with petrifactions; and the fourth sandstone resting on the chalk, and forming

part of the tertiary formation. These species contain varieties, and divisions, and kinds, in subordinate beds.

The second genus, or Gypsum, includes two kinds, one comprehending salt, which is worked as the mineral salt of commerce, and contains other subordinate beds. The second is the flœtz gypsum, and lies above the chalk, being part of the tertiary formation, rarely containing any petrifactions.

The third genus, or Limestone, comprehends five formations of secondary limestones—the first is the mountain limestone of geologists; the second is the magnesian limestone; the third contains the three oolites, upper, middle, and lower, with the lias; the fourth is chalk, which is of three kinds—1. Chalk-marl; 2. Hard chalk, which forms our great chalk ranges; 3. Soft chalk.—The fifth is a formation above the chalk, and is a member of the tertiary series. In the three first divisions organic remains, both animal and vegetable, abound; also impressions of petrified leaves.

The fourth genus, or Trap rocks, is of five kinds —1. Greenstone; 2. Amygdaloid; 3. Wacke; 4. Basalt; 5. Traptuff. These rocks are found in masses, in beds, and in veins of other formations, and contain veins and subordinate beds of other substances. Organic remains do not always occur, but petrified branches have been found in traptuff, and petrified shells in greenstone. Porphyries contain—1. Claystone; 2. Claystone porphyries; 3. Felspar, 4. Felspar porphyry; 5. Clinkstone; 6. Hornstone porphyry; 7. Pitchstone; 8. Pitchstone porphyry. These rocks are very numerous, and occur mostly in columnar and tabular forms; they are found in imbedded masses and in beds and veins of other concretions, and contain pretrifactions of wood.

4. The fourth class, or Alluvial Formation, constitutes the greater mass of the surface of the earth, and is composed of the debris of previously existing rocks broken down by the gradual action of water.

5. The fifth, or Volcanic Formation, comprehends the rocks produced by the agency of volcanoes, and is divided into several varieties, as burnt clay, earth slag, polishing slate: these are formed by the water of hot springs, by torrents of hot water, by mud flowing from subterranean lakes, and by air or mud volcanoes; and, lastly, the volcanic rocks, as lava, tuffa, volcanic ashes, and volcanic glass. Lavas contain—1. Compact lava flowing in the middle of the stream; 2. Vesicular lava, formed by running over moist grounds; 3. Slaggy and spumaceous lavas occur on the surface and in the bottom of streams. Tuffa is a conglomerated rock, with an earthy base, and

contains various volcanic substances. Ashes are the loose powdery earthy matters thrown out by volcanoes in a state of action, and volcanic glasses are lavas which have been in a state of perfect fusion.

All mineral bodies are divided into four great classes:—1. Earth and stones; 2. Saline substances; 3. Inflammables; 4. Metallic ores; and a fifth, or "Petrifactions." Of these divisions, that of earths is much the most numerous, the others occur more or less; but they do not contribute on a great scale to the formation of the figure of the earth or of its surface. Hence the crust of the earth is said to be composed of six substances: Silica, or the matter of rock crystal; Alumina, or pure clay; Iron, Lime, Manganese, and Potash.

The first class, or Earthy minerals, are seven in number—1. Calcareous; 2. Barytic; 3. Strontian; 4. Magnesian; 5. Argillaceous; 6. Zircon, 7. Siliceous. The first comprehends the Limes. 1. Carbonate, containing limestone, spars, and marbles, calcareous tuffa, and common limestone, magnesia, chalk, stalactites, and marls; 2. Sulphate of lime, or gypsum; 3. Phosphate of lime; 4. Fluoride of calcium, 5. Borates; 6. Arseniate, nitrate of lime, and several other varieties and combinations. The second has the carbonate and sulphate of baryta, with divisions. The fourth has seventeen species, as magnesias, serpentine, talc, asbestus, aganate, and smaragdite. The fifth has twenty-one species, as clays, micas, schistus, hornblende, basalt, wacke, lava, lithomarga, or stone marrow. The sixth and seventh genera, yttrian and zircon, have three species, viz., gadalenite, zircon, and hyacinth. The siliceous genus has fifty-seven species, as quartz with varieties; sandstones, flint, chalcedony, hornstone, siliceous schistus, opal and jasper with varieties; pumice-stone, lazulite, felspar, with varieties; topaz, emerald, sapphire and chrysolite, with others of minor notoriety.

The second class, or Salts, are such substances as are for the most part soluble in water, and are characterized by having an alkaline or earthy base. They comprehend:—1. Salts of potash; 2. Salts of soda; 3. Salts of ammonia; 4. Salts of magnesia; 5. Salts of alumina. The first contains nitre or saltpetre; the second contains carbonate of soda, and the sulphate of soda, Glauber's salts, chloride of sodium, common salt, sea salt, or rock salt; the third contains muriate of ammonia, or native sal ammoniac; the fourth contains sulphate of magnesia or Epsom salts; and the fifth contains sulphate of alumina.

The third class, or Combustibles, comprehends diamond, sulphur,

bituminous substances, amber, coals, and graphite. The first division contains the diamond; the second contains common native sulphur and volcanic sulphur; the third contains petroleum or mineral oil and naphtha, mineral pitch, elastic, earthy, and slaggy, bitumens, and asphaltum; the fourth contains amber; the fifth contains coal, woody, earthy, slaty, cannel, and foliated, pitchy and columnar blind coal, conchoidal and slaty; the sixth contains graphite, plumbago, or black-lead.

The fourth class, or Metallic ores, comprehends twenty-three genera. as platinum, gold, mercury, silver, copper, iron, lead, tin, zinc, bismuth, manganese, antimony, cobalt, arsenic, and several others, with divisions and species of those enumerated. The newly discovered metals, calcium, barium, and glucinium, have for their bases the earths whose names they bear.

Petrifactions, which are sometimes as a Fifth class, are fossil substances changed from the parts of animals and vegetables, and contain eight genera:—Anthropoliths, manor parts of man; Zooliths, mammalia or their parts; Ornitholiths, birds or their parts; Amphibioliths, amphibia or their parts; Icthyoliths, fishes or their parts; Entomoliths, insects or their parts; Helminth™oliths, worms or their parts; Phytoliths, vegetables or their parts.

The first genus contains two species. 1. The whole human skeleton changed into a fossil substance. 2. The change of some of the bones or parts detached. The second contains thirteen species of petrifactions of different animals, as the ape, the rhinoceros, and the mouse. The third genus contains petrifactions of different parts of birds, as the beak, bones, and feathers, but are not often met with, though they have been mentioned and described. The supposed petrified birds are often found to be fishes; and birds' nests are found to be calcareous incrustations of modern date. Some resemblance of birds has been found in calcareous stones in England, and in some parts of the Continent. The fourth genus contains ten species of some parts of amphibious animals changed into fossil substances, as the tortoise, the frog, and the crocodile. The fifth genus is rare, and is chiefly found at Monte Valca, near Venice, in Italy, where it forms a mountain of a most singular and isolated nature. The sixth genus contains three species—the crab, or some of its parts, the monoculus and the oniscus. The seventh genus has had fifty species enumerated, with varieties, and consists chiefly in the shell-fish and zoophytes, and efflorescing worms, as the asteriæ or star-fish, the cardium or cockle, the oyster, the helix or snail-shell, the isis or jointed coral, and the

petrified spongiæ and corallines. The eighth genus contains vegetables, or some of their parts, changed into a fossil substance, in six species · 1. The whole plant, as hippuris, galium, aspenula, chervil, anemone, tamarind-tree, the pine, ferns, mosses. 2. The roots of vegetables. 3. The trunks and stalks. 4. The leaves of plants. 5. The flowers. 6. The naked seed, vessels, legumes, nuts, drupes, and cones. Of these petrifactions, some are confined to certain rocks and particular situations.

The formation above the chalk, or what is called the Tertiary Formation, consists of beds posterior to the chalk, and contains —1. Plastic clay and sand. 2. Coarse limestone, with sand and sandstone. 3. Siliceous limestone, with buhr or millstones. 4. Gypsum or marl. 5. Marl. 6. Sand and sandstone. 7. Freshwater limestone, so called from the great quantity of shells of freshwater animals imbedded with the substance, and forming millstones. 8. Brown coal, sometimes covered with a trap-rock or lava. This formation abounds mostly in the vicinity of Paris, and is also found in Hampshire, in the Isle of Wight, and in several parts of the Continent of Europe.

The tertiary system here mentioned forms the fifth and last division, and is restricted to the substances above enumerated, but in many systems of geology the Tertiary Formation includes the above substances, and also the Alluvial Formation, consisting of all the marine, lacustrine, and fluviatile deposits, sands, clays, and all formations above the chalk that do not assume a solid form, and on which no stratified bodies are super-imposed. It lies on the cretaceous system of the secondary series or strata, and the first in order, as the component materials of the earth would be found in proceeding downwards from the surface. The repeated alterations of sand and clay with limestones and sandstones, through all the stratified groups of the cretaceous, oolitic, saliferous, and carboniferous systems, are quite distinct from this formation, which ceases on the occurrence of the first systematic deposition of stratified bodies. The next series in the descending order is the Secondary or Flœtz Formation, comprehending the four systems above mentioned, with the species and subdivisions; and lastly, the Primary strata, comprehending the primitive rocks, with the divisions of fossiliferous and non-fossiliferous, stratified and unstratified, or the Transition and Primary formations together. In the Primary strata, the organic remains occur only in the upper part of the series, and belong to extinct and unknown tribes. In the Secondary series, the remains of animals and plants are very numerous, and are usually distinct, but more approaching

to the existing forms of plants and animals; and the Tertiary formation contains exuviæ closely analogous to existing species. These three leading divisions comprehend all the strata that have been observed, and have been adopted for the sake of convenience, as they express with considerable accuracy the general analogies of origin, composition, and organic contents, which prevail among the members of each divison, but not exclusively belonging to them. The strata are subsequently divided according to the composition, organic remains, position of the formations, and other types and distinctions, as they occur.

Some systems exclude the diluvial and alluvial deposits from the tertiary system, and confine the latter to marine and marino-lacustrine formations of clays and sand, with intermediate freshwater limestone and marls, containing sea and land exuviæ of a date before the present race of sea and land animals came into existence; but as the present genera of animal remains are found in all the strata of the first tertiary formation, though differing in the numerical analogy of the species, all the formations above the chalk have been reckoned a "tertiary formation," being the beginning of the new deposits and of the present zoological period divided into three parts. -the tertiary formation strictly so called · the diluvial and alluvial deposits following in order of formation, according to the revolutions and changes that have happened to produce them.

A new theory, which has been lately promulgated, attributes many of the geological structures of diluvial deposits to the effects of glaciers, which are supposed to have covered the globe during a period of intense cold, and to have retreated to higher latitudes from some change of temperature; this would account for the great mammifers that are found in the polar ice, and in the so-called diluvial formations. Erratic blocks, boulders, and gravels, have, for some time past, been attributed to the same agency. This Theory of Glaciers forms a part of the great problem of geology: it would appear to account for the disappearance of the organic beings of the diluvial period, and also for the disappearance of the great mammifers inclosed in the polar ice: it is associated with the elevation of Alpine countries and the dispersion of erratic blocks, and is also intimately mixed up with the subject of a general diminution of the terrestrial heat. But much extensive observation, and a profound acquaintance with facts, will be required to establish these among the facts of geology.

Rocks are very considerable component parts of the earth, and this is the chief object we have in introducing this sketch of the scene.

Rocks are composed of certain particular mineral substances, which gradually lose their cohesive powers when exposed to certain mechanical and chemical influences. Observation has shown, that by the combined influence of air and water, and of vegetable action, rocks are decomposed, and that the hardest masses are not proof against this change, which will go on with greater or less rapidity according to the constitution of the rocks, and the power of the operating agents of disintegration. "Frost and snow," says Mr. Darwin, "also, partly by chemical, partly by mechanical means, produce the same results both in Terra del Fuego and in the Andes, where the rock was covered with snow* during the greater part of the year, it was shivered into small fragments." Scoresby also observed the same fact at Spitzbergen:—"The invariably broken state of the rocks appeared to have been the effects of frost." In hot climates which produce a luxuriance of vegetation, its progress will be rapid; in cold latitudes it will be much slower; but whether slow or rapid, all substances are liable to decomposition, for even the purest crystal is, by exposure, deprived of its fine polish and brilliant lustre, and a coat of opaque tarnish commences. Lavoisier proved that part of the glass was dissolved in this operation by the boiling water. Soft or porcelain granite has been mentioned, which contains quartz, felspar, and mica. The quartz is almost pure siliceous earth in a crystallized form; felspar and mica are compound substances; and contain silica, alumina, oxide of iron, with lime, potass, and magnesia. By exposure, the lime and potass are acted upon by water or carbonic acid; the oxide of iron tends to combine with more oxygen; and the mica and felspar are decomposed—the latter more rapidly. The felspar forms a fine clay, the mica, more partially reduced, blends with it as sand. The harder quartz will appear as gravel, or sands of different degrees of fineness. The seeds of lichens and of plants floating in the air, fix themselves on the least appearance of earth, and, by their death, and by the carbonic acid evolved, they accelerate decomposition. More perfect plants succeed and perish, and by the combined action of water and acid, with a rapidity proportioned to the alkalies contained in them, the rock continues to be decomposed, and by slow and gradual processes a soil is formed, in which plants and the largest forest trees are produced.

Organic remains are first discovered in the felspar of soft granite and of porphyries. Calcareous matter, the grand supporter of human life, is also first found in the same compound substance, in the ratio of two or three per cent.; and until that means was provided, it would

* Darwin's Voyage of the Beagle.

appear that no animal had lived; but, as it increases, life of every kind becomes numerous and prolific.

It is the generally received opinion, that the formation of soils has proceeded from the detrition of rocks by the force of external agencies; that the disintegrated materials have been carried by floods to the ocean, and there accumulating have been formed into horizontal layers. But the decay of rocks themselves must be very gradual: in some dry countries inscriptions are perfect, and their angular edges and shapes but little blunted or altered, after a lapse of twenty centuries. The formations that are taking place in the present quiescent state of the globe, are made by the sea, fresh-water rivers, and by lacustrine deposits from substances collected and rolled along by the course of the waters over the earth. The depositions go on in many places, visibly, though slowly; but we know little of the processes by which the vast alluvial deposits have been made in all the different arrangements, mixtures, and combinations, to the depth of several hundred feet, and extending over vast tracts of various and discordant qualities; or of the means employed by nature in the process of alluvial deposition from the detritus accumulated at the foot of mountains, from the decomposition of rocks, and of the subsequent removal and consolidation, or even of the operation by which animal and vegetable exuviæ are converted into soil. But these petrifactions and organic remains would seem sufficient to place one fact beyond dispute,—viz., that the globe has undergone many extensive changes; and it is not a little curious that they are confined to particular formations, and are not found in contiguous strata, and that the remains of trees and vegetables are found only in some few similar situations.

Soils are often found to contain substances that do not exist in the rocks on which they rest, and rocks frequently possess materials of which no vestige can be detected in the upper soil, and which, being destructible, would be found in some degree or quantity, if soils were derived from the adjacent formations. These circumstances would appear to indicate that other agents than detrition have been at work in the production and creation of soils.

The alluvial formation constitutes the greater mass of the surface of the earth, and is composed of rocky substances, formed of previously existing rocks, and supposed to be formed by the detrition and ruins of other formations broken down by the gradual action of water. They are loose in texture, and are never covered with any rock or solid secondary strata, and may be reckoned a very recent deposition, the formation of which is still going on. The deposit is mostly composed

of clay, sand, and gravel, which in a great variety of combinations and modifications, constitute what is termed land, or soil. They contain sands from quartz, and clays from the disintegration of slates, felspar, and micaceous rocks, mixed with other substances, and fill up hollow places, and form very extensive tracts. They also contain calcareous tufas, common salt and peat, subterranean and submarine forests, bogs, iron ore, metals, ores, and gems in grains.

In the absence of any kind of certain data to guide the search of inquiry, curiosity will lead to many suppositions--conjecture will be busy, theory will succeed theory--often serving no better purpose than to refute the foregoing, a matter of little difficulty on most points of speculative knowledge. For, after all the extensive investigation and laborious research that have been employed on this subject, it is very probable that the formation of rocks, and the other formations that are supposed to have been subsequently derived from them as well as the process, manner, and operation by which all the formations have attained their present appearance, form, quality, and position, may remain for ever a matter of uncertain speculation, seeing that no analogous formation is now taking place, except in one class of rocks, the volcanic.

In the tranquil laboratory of nature's wonderful and stupendous works, the most sublime harmony and profound silence prevail; and were it not for the admonitions that obtrude on our senses from the lapse of time, the results would scarcely be perceptible. In that manufactory, we do not hear the blast of the furnace, the clank of the hammer, or the reverberation of the stroke. the torture of analysis, the war of the elements, of the acids with the alkalies, is hushed in silence; the use of tests and precipitants, agents and re-agents, is nowhere discovered in producing the work of combination and of dissolution. One grand principle is everywhere at work: pervades every atom and particle—and, in conjunction with the vivifying effects of heat and light, brings into existence, and matures the germs of animal and vegetable life. A modern theory supposes all effects to arise from the motion and reciprocal action of existing substances; consequently, they cannot be produced by natural processes unless the elements already exist. But of the mode of preparation of the various substances for that purpose, and of the state that is necessary to engender life and support it, we are wholly ignorant.

The time that would be required to bring many of the substances that have been enumerated to their present state varies, in different theories, from one year to two hundred years; and the depositions

from twelve inches in one hundred years to fifteen inches in one year. Such wide discrepancies, and contradictory opinions, render any approximation hopeless, and we may very reasonably conclude, that our weak and unassisted reason may never be able to penetrate the veil of obscurity which Nature has drawn over many of her works, and that our labours and researches may never lead to any satisfactory conclusion on the great works of creation;—many of which would appear to be forbidden to man, and destined to elude his curiosity. But such intimate knowledge is not required for the useful purposes of man; external observation and experience afford an abundant source of employment for the time and energies of the human race, and though these abstract speculations have not yet afforded, either from physical or scientific theory, any assistance to the operations suggested by external objects and impressions, yet perseverance may probably lead to a valuable discovery, as has already happened in similar pursuits. Such subjects, even if they never produce any result that is applicable to public utility, are nevertheless in themselves highly worthy the attention and study of rational beings. they enlarge the circle of knowledge, ennoble the sentiments, refine and exalt our ideas, and direct us, with the most profound reverence and devout admiration, to the Great Source of Being, who, from nothing, called into existence the great mass of objects that so very far exceed our comprehension; and who, from all the seeming irregularity and confusion we behold, hath disposed in the most beautiful order and harmony the whole system of creation, teeming with abundance, bestowing life, and affording health and comfort, and the means of existence, to all the numerous varieties of animated and organized life, and forming a source of supply to the inorganic creation of the materials for producing the different substances which, wrought by art and fashioned by ingenuity, contribute so much to the comfort and happiness of man in the numerous and varied departments of civilized life.

CHAPTER II.

NATURAL SOILS.

The foregoing chapter contains a brief history of the art which we are about to describe, and of the opinions that are entertained of the nature and formation of the soil, of which the cultivation will form

the subject of description. These initiatory lessons are more necessary at the present day than before, when the study of the accessory sciences was confined to the recluse and to the amateur, and not spread as now among practical men, and even reckoned necessary for the performance of the art. An acquaintance with them, however slight, is very useful, both to the learner and to the practitioner; they are highly ornamental, and if not required in practice, may easily be laid aside.

Agriculture, or the art of cultivating the earth, is very naturally divided, as before mentioned, into two parts. First, the method of cultivating the earth, and second, the fruits, plants, and animals that are raised and maintained thereby.

The method of cultivating the earth will include soils, and the arable culture bestowed on each description for each crop in succession; the plants sown; the implements used; the use of manures, and of draining as a manure. To the first of these branches we shall now confine ourselves.

It has been very fashionable to give a long and tedious nomenclature of soils, with differences much too minute either for remembrance or use; it must be very inconvenient to harass the memory by loading it with such a number of prolix and cumbersome definitions. Under this impression, we have reduced the distinctions of soils to six, which will be found to express, in a manner sufficiently clear, the soil that is meant, leaving more minute distinctions to the occasion, and to any necessity that may occur for the use of them. Soils are divided—very conveniently for explanation and description—into ARGILLACEOUS or Clayey, SILICEOUS or Sandy, CALCAREOUS, LOAMY, GRAVELLY, and PEAT or MOSS; and to one or other of these classes the numerous varieties of soils in the British Isles are allied, though in many cases the exact degree of affinity may not be easily ascertained.

SECTION I.—ARGILLACEOUS SOILS—PREPARATION OF—ROTATIONS AND SEEDS SUITABLE FOR THEM—CLAY AS MANURE—HOW APPLIED.

ARGILLACEOUS or clayey soils are formed of substances too wet and tough to be reduced for green crops.

CLAY is very tenacious, capable of being moulded, and often containing a larger portion of silica than of alumina, from which the name is properly derived. It has been called *argil*, as being a white earth, and latterly *alumen*, from the word alum, of which it is the

basis. The term alumine or alumina, has been adopted from the French as the scientific name of pure clay, which is now reckoned to be the oxide of "aluminum," one of the lately discovered terrigenous metals, which unites with only one proportion of oxygen in forming this clay, which contains in 100 parts of aluminum, about eight of oxygen. It is the essential constituent of clay, constitutes the basis of alum, and enters into the composition of many minerals: is an abundant earth, entering into many soils and solid strata of the earth, and found pure in the corundum gems, and especially in the sapphire, the colours arising from the various portions of the metallic oxides that are present. "Alumina" is obtained in the greatest purity from alum, which is a triple salt, the sulphate, or rather the super-sulphate of alumina, ammonia, and potash, and contains :—

Acid	30·52	or 26·4	or 34·23
Alumina	10·50	or 12·53	or 10·86
Potash	10·40	or 10·02	or 9·81
Water	48·58	or 51·15	or 45·20
	100·00	100·00	100·00

Or more concisely —

Sulphate of alumina	36·70
Sulphate of potash	18·88
Water	44·42
	100·00

Alum is a solid salt, subacid, known many centuries ago, and used for dyeing: it occurs in masses and in veins—is used in giving a white colour to bread, in preserving animal substances from putrefaction, in making leather and paper, and also as a mordant in dyeing. A solution of alum turns vegetable blues to red, and, when heated in its water of crystallization, it swells and enlarges much, and produces burnt alum, a light porous dry mass. specific gravity, 1·7.

Alumina, which has been mentioned as being the basis of alum, and the essential constituent of clay, is a fine white bland powder, adhering strongly to the tongue, but excites neither taste nor smell. It is insoluble in water and alcohol, but has a considerable affinity for water, increasing in weight about fifteen per cent. by absorbing moisture, and retaining it with great obstinacy; cold contracts it and squeezes out much water, and it loses weight by heat evaporating the moisture; it unites readily by fusion with other earths, particularly with silica, and much of its utility in the arts arises from this power of union. Alumina has a very strong affinity for lime, if it exceeds

the lime in quantity; if the lime be in excess, fusion does not take place. It has a strong attraction for colouring matters, and hence the use of it in dyeing and calico printing; and the union of it with silica and lime forms the basis of all pottery and porcelain, from the coarsest brick to the finest china. Alumina forms a paste with water and hardens by the action of fire, losing the first property by acquiring the second: to regain it, the hardened substance must be dissolved in an acid, and precipitated; it can be made hard enough to give fire with steel, and to cut glass like a diamond; when it contains oxide of iron, it emits the well known earthy smell of clays.

In mineralogy, the clay and lithomarge families are placed in the genus "felspar," from their affinity with the preceding genera, as they have no regular form or cleavage, and are not connected with any of the mineral species. The clay family contains several divisions, of which potter's clay and common clay are only noticed. The former occurs in beds in the alluvial districts colour white and grey, massive, soft, and friable adheres more strongly to the tongue than loam, feels greasy, and becomes plastic in water. it is infusible, and contains, in 100 parts:—

Silica	61	Oxide of iron	1
Alumina	27	Water	11

The uses of it are well known in all pottery wares, in bricks, crucibles, and tobacco pipes, and also in manuring lands.

Pure clay contains, in 100 parts—

Silica	0·45	Oxide of iron	0·45
Alumina	32·5	Sulphuric acid	19·25
Lime	0·35	Water	47·

In the second volume of the *Royal Agricultural Journal*, p. 28, an analysis is given of a clay soil which gave 43 per cent. of alumina, besides other matter quite distinct from sand. Also in the *Rural Cyclopædia*, vol. iv., p. 265, three analyses of soils are given; the first of which, in 100 parts, stands thus:—

Clay	52·4	Carbonate of lime	2·0
Siliceous sand	35·5	Humus, or vegetable matter	7·3
Calcareous do.	1·8		

Common clay is found in vast beds of the alluvial deposits, and is called the argillaceous detritus of glaciers by those who have adopted that theory of the formation of the vast beds of unstratified clays and gravels. It is much mixed with other bodies, and the different colours are partly owing to the presence of oxide of iron, and partly

also to the admixture of animal and vegetable remains in different states and combinations; and there is, perhaps, no substance that enters so largely into the composition of bodies that is found in a greater diversity of composition, in soils, in slates, and all argillaceous formations. It enters into all good lands in fertile soils from nine to fifteen per cent., in barren soils from twenty to forty per cent. The absence of it forms a soil too dry and porous a proper quantity forms the best clays and clayey loams, and a superabundance of it constitutes soils too wet and cold for vegetable life in a moist state; hardening and contracting by heat into a condition that is very hurtful to the growth of plants. The uses of clay in pottery and in brick-making are well known; the red colour of bricks and tiles is owing to the alteration of oxide of iron during the process of burning, the iron being further oxidized by the decomposition of the water applied to the clay in kneading. Calcareous clay effervesces with acids, is more fusible than some others—owing to the presence of lime, and is used in brick-making: meagre clay is gritty, rough, and coarsely granular, and is used for inferior articles, as bricks and tiles. Unctuous clay contains more alumina, and is used for fine or coarse purposes, according to the quantity of oxide of iron which it contains.

The purest clay contains upwards of sixty per cent. of sand, and is always mixed with mineral, animal, and vegetable substances.

Dr. Ure's analysis of clay is as follows:—

Alumina,	16	Iron,	8
Silica,	63	Water,	10
Lime,	1		

It has been observed that alumina, or the basis of clay, has a strong affinity for water and retains it with great obstinacy; and it is this quality which constitutes its distinguishing characteristic. It may be remarked, however, that this quality seems to exist in soils to a smaller extent than is generally supposed, owing to the state of combination and exposure. Clay lands of all colours and qualities are known by their property of holding water very tenaciously, and when once wetted, they are dried with very great difficulty. The most general colours of clayey soils are red and black, of various degrees of fertility and texture. The red soils are hardest—the black are softer and in many cases very waxy and plastic; arising from the minuteness of the particles affording so many points of adhesion. In dry weather they are hard and lumpy, as the red-coloured; in moist weather they dissolve more easily and readily. Clayey soils require much power and labour, and dry weather, if possible, during the pro-

cess of being wrought; and narrow ridging or complete thorough draining in order to carry away the excess of moisture, and give free admission of air into the soil. When enriched with manures, clay soils are naturally well qualified for carrying crops of wheat, oats, beans, and clover, but are seldom or never fitted for turnips, potatoes, or barley, or for being kept in grass longer than one year.

Under able management, when the natural adhesive toughness is overcome, they generally yield the heaviest and most abundant crops. One grand requisite is to keep the land in good condition . a poor worn-out clay being the most ungrateful of all soils. This improvement arises from the withdrawal from the soil of the phosphates and alkalies essential to the growth of the crops. Fallowing, by which soils are exposed for a season of rest to the action of the atmosphere for the purpose of restoring soluble ingredients necessary to produce certain crops, is one of the steps resorted to. The other, which requires the aid of the Chemist, consists in manuring the soil artificially, so as to restore at once the requisite ingredients which the crops have withdrawn.

FALLOWING.—So soon as the grain crops are removed and the harvest finished, all lands intended for fallowing during the ensuing season are ploughed; and this first furrow, or winter furrow, as it is generally called, should not be delayed beyond the beginning of March. An early ploughing is very advantageous; the land has then the benefit of frosts and the vicissitudes of the weather in loosening its texture and in pulverizing the surface. Clay lands are usually laid in ridges of breadths varying from three to eight yards, and, in winter ploughing, these ridges are cloven out or cast two or four together, carefully opening with the plough all the old furrows, that the water may pass freely away. Such lands must be honestly ploughed: that is, the furrow must be clearly moved from below, laid at an angle of about forty-five degrees, and all of the same breadth and depth—about nine inches by six inches. In this state the land lies during winter, until dry spring weather permits of cross ploughing; after which the land is harrowed and rolled alternately, till the clods are tolerably reduced and the weeds extracted; all stones and weeds must be carefully picked by the hand and removed, and the land is ready for another ploughing. These ploughings, harrowings, rollings, and pickings, are renewed during summer, as the state of the land may require—the last ploughing covering the dung, which is usually applied in August or September. The dung is usually prepared in a heap in a corner of the field, and is laid on the land in small heaps in

single rows on the ridges of the land, and immediately spread out by labourers, while the covering ploughs follow closely. The quantity of farm-yard dung applied may be averaged at fifteen cart loads, drawn by two horses, to the acre. Lime, if any be applied, should be laid on the pulverized surface of the land, and harrowed in before the dung is laid on: and thus the two manures come in contact, and are incorporated with the soil before the seed is sown. In October, the land is ploughed for seed, the ridges are gathered, and the furrows very carefully left open: the sower follows, distributing the seed at the rate of two bushels per acre, the harrows following all close the scene. The drawing of the water furrows should not be long delayed, in order to guard against heavy falls of rain, which, by stagnating on the land, may do much injury. The cross cuts in hollow places, and the openings inside and across the headlands, must also be executed without delay by the spade, for the purpose of quickly discharging the water.

Wheat is the plant universally sown on clay fallows: on some inferior sorts of land, and in high latitudes, oats are sometimes sown in the spring, and in midway situations barley is occasionally used. Winter tares are also sown on the wheat stubble, and beans are sown in the spring, broadcast, dibbled, or sown by machine on the harrowed surface. Clovers are sown with the wheat in the spring, in order to be as little removed as possible from the cleaning and manuring process.

Clay soils require the whole of the summer season to prepare them for the reception of the seeds, and differ therein from the loamy and sandy soils, which, from their natural looseness of texture and dry constitution, are capable of being cleaned and pulverized at an earlier period, and of being planted with crops, which arrive at maturity the same season. The process of cleaning and pulverizing clay lands during summer is termed "summer fallowing," one of the oldest practices on record, and at this day one of the most useful and the most necessary. Many writers, and even some practical men, have argued very earnestly that "summer fallowing" is unnecessary, and that all lands are capable of being planted with green crops, or cultivated by the row culture as profitably as by summer fallows. But, in making this assertion, they have only shown their total ignorance of the soils in question, and that they have never cultivated the lands on which they pretend to pass judgment. The arguments *pro* and *con* would not much enlighten the practical reader—it may be sufficient to state the fact that there are soils, and in very considerable

quantity, which no power known to us is able to reduce for green crops; and, when reduced, the texture is too firm and tenacious for the tender roots of delicate plants. On such soils "summer fallowing" is indispensable—no course of cropping, no mode of cultivation yet devised, is able to remove it from our practice, and all attempts to do so have ended in loss and retrogression. Much of the prejudice against "summer fallowing" has arisen from the bad performance of it; but in the whole course of improved husbandry there is not a more pleasant object to behold than a well executed "summer fallow," ready for the reception of the seed.

The system of a rotation of crops is supported by the strongest evidence that different crops withdraw the natural ingredient of the soil in unequal quantities. Boussingault found that the five following crops grown in succession on an equal surface of the same field, once manured, removed from the soil:—

			Ingredients of the Soil.
1st	year's crop,	Potatoes, tubers only . .	246·8 lbs.
2nd	,,	Wheat with straw and corn .	371·0 ,,
3rd	,,	Clover	620·0 ,,
4th	,,	Wheat	488·0 ,,
		Fallow and Turnips . .	108·0 ,,
5th	,,	Oats, corn and straw . .	215·0 ,,
	A crop of	Beet, without leaves . .	399·6 ,,
	,,	Peas and straw . . .	618·0 ,,
	,,	Rye, Helianthus tuberosus .	660·0 ,,

These figures represent the organic portions of soil taken up by the different crops, as found in their ashes. Wheat appears twice, showing a difference of 87·0 between the first and last, arising from the unequal quantities of straw and corn produced. According to this view plants require certain constituents in the soil in order to reach maturity, and that without them no perfect seeds can be formed. By adopting a rotation the period of exhaustion is diffused.

In stating the rotations of crops adopted on clay soils, we shall assume two sorts or qualities, and distinguish the crops according to the quality of the soil:—

I.—Rotation of Six Years.—1, Fallow, dunged or lime, or both.—2, Wheat. —3, Clover.—4, Oats.—5, Beans.—6, Wheat.

II.—Rotation of Four Years.—1, Fallow.—2, Wheat.—3, Clover, peas, beans, or tares.—4, Oats.

III.—Rotation of Six Years.—1, Fallow.—2, Wheat.—3, Beans or peas.— 4, Barley.—5, Clover.—6, Wheat.——Or: 1, Fallow.—2, Wheat.—3, Peas.—4, Barley.—5, Hay.—6. Oats.

IV.—Rotation of Five Years.—1, Fallow.—2, Barley.—3, Clover.—4, Beans, peas, or tares.—5, Wheat.——And also. 1, Fallow.—2, Barley.—3, Peas, beans, or tares.—4, Wheat.——Or: 1, Fallow.—2, Wheat.—3, Peas.—4. Oats.

V.—Rotation of Eight Years.—1, Fallow.—2, Barley.—3, Beans.—4, Wheat.—5, Tares.—6, Barley, dunged on the stubble.—7, Clover—8, Beans.—9, Wheat.——And: 1, Fallow—2, Wheat—3, Beans.—4, Barley.—5, Clover, dunged.—6, Oats.—7, Beans; 8, Wheat.——And also: 1, Fallow.—2, Barley.—3, Clover.—4, Beans, dunged.—5, Wheat.—6, Tares.—7, Wheat.——And: 1, Fallow.—2, Wheat.—3, Beans.—4, Barley.—5, Clover, dunged.—6, Oats.—7, Beans, drilled.—8, Wheat.

The following course possesses much merit, and joins the bean and pasturage farming—a circumstance that is very seldom, or rather never met with:—

1, Fallow, dunged.—2, Barley.—3, Grass—4, Grass.—5, Oats.—6, Beans, drilled and hoed and dunged.—7, Wheat.

The crops are well varied, and the land derives the advantage of rest in pasturage, which refreshes it more effectully and durably than any course of manuring. By sowing barley, the objection is obviated of grass seeds not succeeding well on a wheat tilth, and wheat after beans is most generally a successful crop. A better course can hardly be devised.

On inferior clay soils, the following rotations are applied:—

I.—1, Fallow.—2, Wheat.—3, Clovers, trefoils, and cinquefoil.—4, Clovers, trefoils, and cinquefoil.—5, Wheat or oats, peas or beans, and tares.

II.—1, Fallow.—2, Oats.—3, Grass.—4, Grass—5, Grass.—6, Beans, drilled.—7, Wheat.——And also: 1, Fallow.—2, Barley, wheat, or oats.—3, Clovers.—4, Clovers.—5, Oats.

III.—1, Fallow.—2, Wheat.—3, Seeds, mown or pastured.—4, Pasture.—5, Peas, beans, or tares.—6, Oats.——Or: 1, Fallow.—2, Wheat.—3, Seeds.—4, Pasture.—5, Oats.——Or: 1, Fallow.—2, Wheat or Oats.—3, Seeds, mown or pastured.—4, Peas, beans, or tares.—5, Oats.——In high latitudes: 1, Fallow.—2, Oats or barley.—3, Seeds.—4, Pasture.—5, Pasture.—6, Oats.

The following list of grasses are proper to be sown on the better clay lands.—

For hay of one year: 1 bushel of ray grass; 16 lbs of red clover; 6 lbs. white clover.

The white clover may be omitted; the quantity of red clover may be diminished; and a greater mixture of grasses may be added. Thus:—

2 pecks of ray grass; 2 pecks of cocksfoot; 4 lbs. of meadow fescue; 4 lbs. of meadow catstail; 10 lbs. of red clover.

On Inferior Clays.—For hay and two years' pasture: 1 bushel of ray grass, 6 lbs. of red clover, 4 lbs. of white clover, 2 lbs. of catstail, 2 lbs. crested dogstail.——Or for longer pasture, ½ bushel of ray grass, ½ bushel cocksfoot, 6 lbs. of dogstail, 4 lbs. of catstail, 4 lbs. of meadow fescue, 6 lbs. of red clover, 4 lbs. white clover.

Grass seeds must be well mixed, and sown with a machine; which is a very great improvement over hand-sowing. In the spring, the wheat grounds are stale, and should be harrowed before the seeds are sown, in order to produce a tilth; and then harrowed again after the seeds are sown, and finished by a heavy rolling.

Sandy soils are composed of the rough, dry, and hard granulations of stones that have been disintegrated, broken, and reduced to particles, by the action of the various agencies supposed to have contributed to the formation of the different substances found in the composition of the globe. Sands are much mixed with other substances, and accordingly vary much in colour; white, red, yellow, brown, black, and green, with many varieties, as the chief colouring qualities are wanting or abundant. When more unequally reduced, sand forms gravel; when composed mostly of flints, it is called siliceous: with mica, it is micaceous; and when very finely reduced, [illegible]itutes dust and quicksand. The chief use of sand in the arts [illegible] making glass; it fuses readily with soda, forming white and gr[illegible], according to its composition. Sands do not effervesce [illegible] n acids, and are not dissolved or disunited by water, or any way altered by it; with lime, it forms mortar, and it enters into the compos[illegible]on of porcelain and pottery.

Sandstones form a very large part of the secondary or floetz [illegible]cks; and are divided into the old red sandstone, the new red, the greensand, and the alluvial deposits resting on the chalk. These rocks are siliceous, argillaceous, marly or calcareous, and, according to hardness, and composition, are converted to various uses in building, and for pavements, troughs, and filtering-stones. Some harden by exposure, and others decay; and vast beds of incoherent sands are found above and under chalks and clays, and of various colours and qualities.

Clay is applied to land in three ways: in an unmixed state—1st, as it is found; 2nd, in a compost with lime and other substances; and 3rdly, in the shape of ashes burned in a kiln. In the first mode it is applied as a corrector or improver of the texture of light or sandy soils. The value of the application will depend on the quality of the clay, for no substance is found in greater diversity. If the clay be of a calcareous nature, it will resemble marl in its effects; while ferruginous clays, and those of a white sandy nature, and many gravelly clays, are positively injurious; and it is only when clay has acquired a solid consistence, more or less unctuous and friable, that the application of it can be prudently recommended. From sixty to one hundred loads per acre have been used on sandy soils with much

advantage; and autumn would seem to be the best season for application, or in the beginning of winter on sands and in light loamy soils, when the action of the weather will assist in reducing the adhesive mass, and an opportunity will be afforded of the clay being mixed and amalgamated with the soil during the working of the land for green crops. Much difficulty wlll occur in reducing to particles the clammy or indurated texture of the clay; and without due attention to the application, and without a liberal quantity being applied, little or no benefit may be derived.

In mixing clay with lime in compost, a very liberal quantity of lime must be allowed, in order completely to break asunder and reduce the clay into a saponaceous unctuous mass. The heap must be repeatedly turned over, and well broken and mixed, and sufficient time allowed for combinations taking place.

For the purpose of reducing clay to ashes by calcination, kilns are built of an oblong shape with bricks, in the manner of a gridiron floor, with flues placed longitudinally and transversely, and with a chimney at the end opposite the furnace. The flues are arched, in order the better to sustain the weight of the clay; the size may be twenty feet in length, twelve in breadth, and four feet in height, which will burn about two hundred cart-loads of clay, and will cost about £10 in the erection. The expense of burning will vary with the cost of fuel: it has been rated at 6d. to 10d. per cart-load, exclusive of the cartage. It is, however, no uncommon thing to burn clay without a kiln. A little fuel only is used at first, under which one or more rows of tiles are laid to admit a draft of air. The fuel is covered all over with clay, and as the fire shows itself in the heap fresh clay is heaped on, the heap becoming wider and higher; and this may be continued so long as the clay can be thrown or wheeled to the top. Some kinds of clay require an admixture of small coal to make them burn, but many kinds require no such aid, the principal secret being to exclude the air at the sides and top, and admit it freely below. But, however burnt, when the clay is calcined the fire is to be extinguished, and the ashes will require a time to cool before application.

The ashes of clay as a manure was greatly lauded in the agricultural world some years ago, but have now fallen, according to the judgment of the sober maxims of prudence. Burnt clay possesses none of the caustic solvent properties of calcined lime; the water has been banished by the application of fire, the earths are reduced and divided into minute particles, and invested with an unknown property which substances acquire that have undergone the action of fire,

and it is supposed that it attracts and retains the ammonia conveyed to the soil by rain-water, and thus affords to plants the nitrogen contained in the ammonia. The clay must be as completely powdered as possible, and may be applied on fallow land with any green or grain crops. It can only act mechanically as an alterative in rendering the soil more friable, as its particles seem to have lost the power of coherence, and lie compact, for a time at least, without uniting; but in order to effect any permanent benefit, the quantity should not be less than from thirty to sixty loads, varying from six hundred to one thousand bushels per acre.

SECTION II.—Marl—Its Constituents—Sandy Marl—Clayey Marl—Shelly Marl—Its Uses as a Manure.

Marl is a calcareous earth, or carbonate of lime, with portions of other earths; in geology, it is placed in the tertiary formation, resting upon the gypsum and alternating with it; one bed is white and calcareous, and contains silicified trunks of trees and species of plants, and fresh water shells, the other beds are argillaceous and of great thickness, and sometimes contain balls of celestine, or sulphate of strontites. Thin beds succeed, the uppermost of which contains great quantities of oysters. Marls lie in the second and third beds of this formation; and the former is called a fresh water formation, from its containing few other petrifactions than those of fresh water and land animals—the latter joins with the sands and sandstones, and contains marine shells. The fourth and last bed of the formation, is a large one of the fresh water denomination. Marls are usually divided into two kinds, clay or earthy marls and indurated marls, divided into shell, slate, and stone marls. The clay marl is supposed to have been formed by the slow deposition of clay suspended in water, and mixed with the particles of decomposed shells. When these shells have retained their form it is called shell marl. The peculiar advantage of marl is its readily crumbling to powder when exposed to air and moisture. The latter, which does not crumble in the air, is sometimes spotted reddish and brownish in the rents, and marked with dendritic delineations; but most commonly smoke-grey, bluish, and yellow in colour, and much resembles compact limestone, occurs massive in angular and vesicular pieces, and in flattened balls, and contains animal and vegetable impressions; fracture earthy, passing into splintery, mostly thick and straight, slaty, uneven, and conchoidal; texture generally slaty where there is little clay, not crumbling in the air; fragments angular, blunt, tubular, discoid, laminar and slaty, opaque,

yields to the nail; streak, greyish white; feels meagre, easily frangible, and rather brittle. It effervesces briskly with acids; intumesces before the blow-pipe, and melts into a greenish black slag, and contains:—

Carbonate of lime	56
Silica	12
Alumina	32
	100

And often some iron and manganese.

Marls, in which the calcareous earth predominates, are called calcareous marls; where aluminous earth predominates, it is called clay marl; and ferruginous, where there is a considerable mixture of oxide of iron. Aluminous and calcareous marls are used for the purpose of mortar and in pottery, and in smelting iron; but the principal use is in agriculture.

Earthy marl is of a whitish yellowish-grey colour, or yellowish-white, sometimes smoke-grey—these are the colours when dry—when moist in its bed, it is generally blackish-brown, or brownish-black. Some varieties are generally of a brown colour, and emit a urinous smell; and by some it is considered an earthy stinkstone. The colours are lighter than those of the indurated marl, and it consists of dusty particles, loose or feebly cohering, feels fine, rough, or meagre; soils slightly, and is light; often mixed with mica, gypsum, or sand—with the latter, fusible into glass; sometimes contains iron, but very rarely other metals; contains sixty to eighty per cent. of mild carbonate of lime; it effervesces strongly with acids, and is composed, besides lime, of bitumen, alumina, and silica—sp. gr. 1·6 to 2·4; when dry it gives out a strong urinous smell, but loses that quality by exposure. It occurs in strata and in beds in the flœtz formation, and in limestone formations along with the stinkstones, and in sandstones, and often immediately under the vegetable earth, and abounds in many parts of the continent of Europe. The two kinds of marl pass into each other: the earthy being reckoned to be produced by the decomposition of the indurated—but the two kinds do not always accompany each other. The component parts of marl are so minutely divided as to be invisible to the naked eye; and from this circumstance, and from their containing both fresh and salt water organic remains, and from their fissile structure, it has been conjectured that they have been produced from the detritus of other substances, and that they have subsided from a liquid state. This supposition is strengthened by the circumstance of the substances occurring among

the flœtz or secondary strata. They are soft and opaque; earthy light, and miscible with water by agitation; soluble in acids with effervescence; harden in the fire, and vitrify with a strong heat; and, to constitute true marls, the substances must contain as much clay as to fall into a powder in water, and crumble into minute pieces by exposure to the air, and generally showing a hoary congelation from the effects of the rays of the sun. The quantity of calcareous matter varies from two thirds to four-fifths, and it may be separated by using almost any of the acids, and it will wholly dissolve that substance and leave a residue of clay, which is composed, as usual, of alumina and silica.

Marl in agriculture is divided into stony, sandy, clayey, and shelly marl, according to the appearances it assumes in different situations, where it is found at various depths under the ground. The first kind is often called *rotten limestone*, and is thought to owe its hardness and slaty or laminated texture to the presence of sand along with the calcareous and argillaceous ingredients: it is slow in operation, but lasting and very favourable to the production of grasses after a long period of time.

Sandy marl is most frequent in Ireland, and in pits of limestone gravel, and is called limestone sand. The colour is brown, blue, or black, sometimes like lead; contains more sand than clay, and consequently is not unctuous, and does not adhere to the tongue; feels gritty, and slowly crumbles and moulders when exposed to the air. It does not effervesce much with acids, as the quantity of sand usually amounts to sixty or eighty per cent.: on clayey stiff soils it has very much improved the texture of the land when liberally applied.

Clayey marl is found of different colours, yellow, blue, red, and brown, occasioned by the substances to which it has been exposed, and by the subjacent and superincumbent formations; it contains more clay than other marls, generally sixty to eighty per cent., and twenty to thirty-two of carbonate of lime, and eight to ten of sand, with some signs of iron, and consequently possesses a greater power of absorbing and retaining moisture; it has a soft unctuous feel in its original moist state; is flexible like a paste, but dries and crumbles on exposure: the effects of it on all light and thin soils, sands, gravels, and loams, are great, as the portion of clay adds to the bulk and consolidation, and benefits the land by moisture.

Shelly marl is found generally in places that have been covered with water, and is supposed to have proceeded from testaceous

animals, being composed of shells converted into calcareous earth, more or less refined and pure, according to the attrition and decomposition they have undergone during a long period of time, and according to the quantity and quality of the substances that are mixed with them by the decomposition of the earthy and muddy matters left by the sediment of the waters. This kind of marl contains more calcareous matter than the others—generally more than the ordinary limestones. Most marls effervesce in acids when fresh: after burning, the ebullition ceases. But several varieties are used that show no affection by acids, and yet have been long celebrated as manures. Clay marl effervesces feebly, and hardens in the fire, while the more calcareous sorts dissolve into powder; and all marls are easily vitrified and crumble by exposure according to the solidity of the texture, and when burnt, soon fall by the attraction of moisture, and feel greasy when they contain any particles of mica. Marls are generally found in a moist state, especially the argillaceous sort: they soon crumble by exposure, but lime is not altered. After calcination, lime falls into powder by the agency of air and water, but marl suffers no change. Ancient records inform us that marl has been very early and extensively used in Britain, and it is yet applied in some places, though in a great degree superseded by the use of lime, which, by burning, is rendered lighter and of more convenient carriage, while the crude heavy state of marl, and the large quantity required for an effectual application, confine the use of it to the localities where it is found. For the sake of conciseness, marls may be divided into two kinds for practical purposes,—the shelly and the earthy: more minute accuracy will make many divisions, but these two now mentioned will mark a sufficient distinction, according as the marls contain more earths or lime in their composition. Shell marl is generally found under mosses and at the bottom of lakes, and of a bluish white colour, and seems to be a natural deposit where water has been stagnant. The composition usually partakes of the nature of the surrounding earths, and may be properly considered as a compost of organic matters, with earths and calcareous matters reduced without the action of fire, and for this reason it would seem to form a manure of very superior quality. It often occurs in ponds and in land-locked bogs, on the sides of hills and on the banks of rivers, formed by the accumulation and decomposition of small shells, as of wilks and periwinkles, and also bivalves, and lying in beds of different thickness, running horizontally, but seldom of great extent.

In Ireland, marl lies sometimes within two or three feet of the

surface; in low bogs, and in other places, at a depth of six to nine feet. To reach the true marls, several strata are pierced—turfy earth, then gravels, moss, fossil wood, sectile by the spade, and a vegetable stratum of seeds, leaves and berries; then clay with shells, which is used as marl; and then the proper marls, in beds of some four feet or upwards in thickness, often containing horns of deer. Marl from below mosses has been found to contain as much as eighty-four per cent. of pure lime, which is more than is found in the purest limestones. By other trials, shelly marl gave,—

Lime	41·25
Carbonic acid	32·
Silex	14·
Argil	4·
Oxide of iron	2·05
Inflammable matter	2
Loss	4·70
	100·00

In such situations, the depth at which the marl is found prevents it from being much used; and the weight of the substances and the quantity required render the carriage very expensive.

Clayey marls are found under mosses, and in low wet places at the foot of hills, and in the valleys between them. The composition and quality varies much—from fifteen to forty per cent. of calcareous matter has been stated as an average, and the remainder consisting of clay and sand; but there are often found mixtures of sand, loam, clay, and chalk, in different quantities, according to the nature of the animal, vegetable, and earthy matters which abound in the locality, and which have been collected and decomposed together. Separate and distinct beds of clayey and sandy marls have been found alternating with clays and limestone, of which clay is the undermost stratum; the marl being of very different colours, as it has been exposed to the elements composing and surrounding it—the redness showing the presence of iron the whiteness that of lime, the blue or yellow showing the clayey composition mixed with other substances. It is sometimes found very hard to dig, with lumps of chalk and limestone in it, lying under stiff clays and low black earth, and very compact and greasy—an excellent manure for sandy lands. It is also found breaking into lumps like dice, or flakes like lead ore, or of a reddish colour, and smooth in the surface, soon crumbles, and is of very good quality. Other kinds are found not so soft and unctuous as to be delved and cut out by the spade; and shale or flag marl, of bluish colour, is often found on the sides of hills, and near rivers, of very good quality,

and lasting; it is very easily dissolved, and falls down very readily by the influence of rains and frosts. A mixed marl has been found to contain:—

Fine sand	36
Clay of a soapy kind	44
Mould	5
Carbonate of lime	14
Gypsum	1
	100

The mixture of the particles of the different ingredients found in earthy marls is so minute and fine, that not only the eye, but the microscope fails to discover the constituents of any of the substances, and chemical analysis only is able to separate and detect them. Mixtures of clay and lime, in alternate layers, have been recommended and employed to produce an artificial marl; but the properties are wanting, and the true character of all marls, is that of crumbling by exposure,—as all calcareous earths are not marls. We are wholly unacquainted with the natural process of their composition. We may very justly suppose that that operation imparts qualities unknown to us, and which we cannot imitate. The operations of art fail when brought into competition with the modes of working adopted by nature. The combination and resolution of rocks, stones, and earths into each other, which goes on incessantly, not to mention the changes of the mineral, the animal, and the vegetable world, has never been approximated in the most distant degree by the labours of man. Mortars and cements are a resolution and combination of this kind; and though the original constituents be known and applied in the same state and proportion, we cannot produce the original substances. With powdered lime, carbonic acid, and water, and with the other ingredients all used in the definite proportions, the limestone will not be composed by any means that we can adopt.

Clay has been found of a soapy nature, and has been often mistaken for marl; but it is found to be hurtful to vegetation, from containing sulphur and other mineral substances; and, in such cases, a chemical examination of it will be necessary before application.

Marls of several kinds abound in Norfolk, are of good quality, and have been much used. The chalk marl breaks readily in the air, and incorporates easily with the soil, falls in water, but does not dissolve in it; burns to lime, and loses more than one-third of its weight, and is used as lime for a manure, and in building, and is similar to common chalk lime.

Clay marl found in that county breaks into small square pieces, and mixes freely with the soil; falls, but does not dissolve in water, and burns to brick in the fire.

A kind of marl called *dove-marl*, from the resemblance to pigeon's dung, has been found to be of very excellent quality; and the chalks of Norfolk are also very pure, containing as much as ninety-eight parts of carbonate of lime. Marls exposed for years retain the same properties as when newly dug, do not effervesce after calcination, and good marls feel greasy when touched, and friable when dry, and the land is usually of good quality above them, and the red and blue colours, with yellow veins, are found to be the best. Marls are known by breaking into small pieces from exposure, by the particles of dry marl crackling in the fire like salt, by throwing up bubbles to the surface of the water in which it is immersed, and by gradually dissolving and forming with the water a soapy substance like a paste, and not unfrequently of a liquid nature, the marl remaining dissolved and suspended in the water without any coagulation. But water alone will produce bubbles when poured on certain dry clays; hence it is recommended to subject marls to water for a time before being tested by an acid. Marl contains no alkaline salt, as it imparts no quality, smell, or taste, when digested and boiled, and has nothing soluble in water. A more correct method of distinguishing marls has been mentioned,—by banishing the fixed air from a certain quantity of the substance by applying muriatic acid, till the effervescence ceases; the loss of weight will show the quantity of air expelled, and the remainder is earth. The quantity of calcareous earth may be ascertained by dissolving the marl in muriatic acid, diluting the liquor with water, passing it through filtering paper, and then precipitating the calcareous earth from the clear liquid by a solution of some fixed alkaline salt.

Marls much abound in the eastern and western counties of England, and in many parts of Scotland, where the beds are shallow, and the presence of it suspected, time and accident and intentional research have discovered the substance; but where it lies deeper, the boring-rod is the surest guide. Pits are opened with a sloping entrance in fields where marl is found, and it is dug and wheeled on the land, or conveyed by carts to a greater distance. The quantity used upon an acre of land varies from ten to one hundred loads, of thirty to forty bushels each; and forty to sixty cart-loads, of two or three horses' draught, may be stated as an average, which will add very considerably to the bulk of the staple of the soil; the quality of the land and of the marl, and the expense of the article, will, in different situations, have the

usual influence, the expense varying, according to circumstances, from £2 to £6 an acre. It is applied on land, after tares, for wheat, and on a clean fallow, and as a preparation for barley and turnips, where the shallow ploughing of the last furrow is very suitable for covering the marl. A preferable application is recommended on clover leys intended for wheat, where a period of six months before the land is ploughed will be of great service in crumbling the marl by the alternations of thaws and frosts, and in securing an even and regular distribution over the surface. An objection arises to this method,—that the marl has not had sufficient time to fasten on, and adhere to, the ley; it lies loose, and will be thrown to the bottom of the furrow, without any chance of exerting a fertilizing influence, by reason of not being mixed or blended with the soil. In the application to barley and turnip lands, this objection does not happen, as the marl will get blended with the pulverized soil by means of the ploughings and harrowings; but there is not a sufficient time for the marl to dissolve and mix, unless it be dry, exposed, and turned over in heaps some time previous to the application, which will add considerably to the cost of the manure. A more effectual and more economical method consists in laying marl on grass lands in the end of autumn, and during the first months of winter, when the grass will be of little value, and when the changes of the weather will effect the decomposition of the marl by the time the grass will shoot up in the spring. It will thus secure the regular spreading over the surface, and the bush-harrow and the roll being afterwards employed, the particles will be well reduced and pressed into the soil. The crop of grass will be greatly improved, and when the land is ploughed for a grain crop in the following season, the marl will be thoroughly matted in the turf, and the vegetable sward it has raised will not a little promote, by its decomposition, the subsequent fertility of the land. This mode is preferable in affording time for the crumbling of the marl. The application on barley and turnip lands in the spring admits a finer mixing, provided a suitable reduction of the substance can be accomplished, which probably may be done by exposure from spreading and turning in heaps on the land between the two last ploughings, if favourable weather happens, and when the composition of the marl itself favours the speedy dissolution. This result may be much assisted in the spreading, and by going over the work with mallets, and breaking the lumps in the same manner as chalk. In whatever manner it may be applied, it is indispensably necessary that marl be reduced as fine as possible, by even spreading and breaking the lumps, by rolling and

harrowing when dried after rains, and by being ultimately ploughed into the land by means of a shallow furrow, and thus be intimately mixed with the soil by means of the future operations. Some marls will crumble to powder immediately on exposure, or very soon after; others require the vicissitudes both of winter and summer, and much attention in improving the crumbling action of the weather, by breaking, harrowing, and rolling.

Marl being a carbonate of lime in a peculiar state of composition, produces effects similar to those produced by that substance, but it requires to be applied in a much larger quantity. Though it is a rich manure, it contains no salts, and is supposed to possess a quantity of oleaginous matter, and to be an absorbent earth composed of clay and limestone. The chemist ascribes the whole value of it to the action of his favourite calcareous earth in the character of a stimulant, and that the value of marl is in a direct ratio to the quantity of that earth in its composition; but marls are found which contain little or no calcareous earth, and when applied to land in equal quantities, they produce equal results.

The effervescence of calcareous substances in acids, shows the presence of the substance, not the quantity; the effervescence will vary according to the strength of the acid, the compactness, penetrability, and other latent qualities of the calcareous bodies themselves. The chemical agriculturists adopt the notion of the action of calcareous matters, and join with it the bulk, or addition, which the soil receives by the application of the substances; the change it creates in the texture of the land by mechanical action, and a mucilaginous matter that it contains derived from the exuviæ of animals, and they are finally driven to the very reasonable conclusion, that the benefits may be produced by the joint action of all these modes of operation. If the component parts of any marls,—the clay, sand, and lime, and the other ingredients,—were spread on land, separately or mixed by any process we may choose, and the definite proportions multiplied by the quantity usually applied on a given extent of space, the effects that are derived from true marls would not be produced. The extremely minute blending of the ingredients of marl has been supposed to constitute the fertilizing quality, each particle having the power of exerting its peculiar property on the soil and on each other, and of retaining or giving out the substances they may form that are favourable to vegetation by the different agencies and combinations. The clays impart moisture to the sandy parts, and the sand prevents the clay being too adhesive, and thus the respective qualities are exerted advantageously

on each other. An oleaginous nature has been discovered in the composition, arising from the mixture of the substances, and of the animal and vegetable matters, and to this property much of the fertility it produces has been attributed. Marls are supposed to be derived from the ruins of the primary and secondary rocks, worn down, carried about, agitated, and deposited without any relation to the laws of specific gravity. Animal remains are found at considerable depths, and even stones of great weight are met with, where no rocks of the same, or of a similar kind, are known to exist in the surrounding locality, or in the adjacent geological formations. Fire wholly changes the nature of bodies subjected to the violent effects of its influence, and gives them qualities they did not before possess, and banishes others which they never afterwards recover. Decomposed lavas are exceedingly fruitful, and the heat of volcanos produces a most luxuriant vegetation in all places within its reach; and it has been fancifully conjectured that marl may retain some of the qualities which its constituent substances acquire as rocks by the igneous agency of their production. Such conjectures amuse the theorist, and interest the curious, but can furnish no information as to the quality of marls, or of their effects when applied on the different soils; on these points we must turn to true science, or the systematized experience [illegible] practice.

[illegible] up for the purpose of improvement. The effects of marling have been great; and on sandy lands [illegible] and on sandy loams, the applications have been very beneficial, while on raw damp loams reports have been less favourable, from the marls attracting moisture, and thus increasing the poachy looseness of the soil. Clay lands are also much improved by marls when applied in large quantities; but the due effect supposes a somewhat similar pulverization of the clayey mass to facilitate the fertilizing mixture of the substances. Practice has directed the use of clayey marls on light soils, and the application of sandy and shelly marls to heavier lands; but all these substances have been found useful on any soils when judiciously employed. The hurtful effects of marls have been occasioned by an avaricious use of the plough, and a too frequent sowing of corn crops—which evil has been completely remedied by adopting the alternate system of cropping, and the land lying in grass for more than one year. It may be more advantageous to apply marls gradually, and at different times, than in very large doses at one time, which in some soils may produce looseness and prove hurtful.

Marls are often made into composts with earths and with dung, either in layers in the heaps, or in bottoming the dung-yards, where it will be soaked with the juice, and afterwards mixed with the mass. It is thought that such a preparation has produced effects, when marl, by itself, has failed. In all such applications, one thing must not for a moment escape the memory of the farmer, that the lands must be supplied with animal and vegetable matters by every possible means, and that in the case of light lands too frequent cropping with culmiferous plants will infallibly exhaust them, and that they require the constant aid of the green crops being consumed upon them, and of the consolidation produced by remaining a time in pasture, and of the consequent result of a grassy sward to produce vegetable mould by the subsequent decomposition of the roots and foliage.

Great improvements have been made in Norfolk by raising and mixing the subsoil with the upper stratum, and in many parts of the kingdom clays are preferred to marl; but such clays are soft and loamy, and effervesce slightly with acids. A marl has been found in the west of England, of a red shining clay colour, which has proved very injurious, and the use of it is now interdicted. Marls in general have produced very great effects, and are now applied more frequently and in smaller quantities.

SECTION III.—Silicious Soils—Management—Crops suited for them—Sand as Manure.

Silica is the pure matter of flints, occurs massive, often globular and perforated, containing a small portion (about two per cent.) of lime, alumina, and oxide of iron. It is wholly infusible, and dissolvable only by hydro-fluoric acid. It enters largely into the composition of stony bodies and into soils, and many gems, as agate and jasper—while flint, quartz, and rock crystal, are almost wholly composed of it. It is now called the oxide of silicum, a terrigenous metal, because it is the basis of the earth. It has been called silicon, being analogous to carbon and boron, the bases of carbonic and boracic acids, the vitrification being a complete saturation. Silex acts as an acid, and therefore is frequently called *silicic acid.*

It is suspected that carbon can be converted into silicon, and that some elementary bodies are only modifications of others, and are constantly changing their condition. Flints would thus be derived from animals by the conversion of the carbon of their bodies into silicon, produced by unknown causes, as the heat of the overlying igneous rocks. It must be confessed, however, that further experiments are

required before these speculations can be received into the category even of philosophic theories.

Silica is a most abundant earth, forming a great proportion of the primitive rocks, and the basis of the globe. In fertile soils it averages fifty to eighty per cent., in barren lands forty to seventy, but these proportions never mark with precision the quality of the soil,—very much depending on the mixture and combination, and on geographical position. Silica absorbs 0·25, or one-fourth, times its weight of water without dropping, and evolves water twice as fast as chalk, and three times faster than alumina.

Many sand-beds and sandstone formations are evidently original deposits; many kinds are products of chemical and crystalline formations; and we must not conclude that sands have originated wholly from the ruins of pre-existing rocks. Sandstones form a very large part of the secondary or flœtz rocks, and are divided into the old red sandstone, new red, green sand, and the alluvial deposit resting on the chalk. These rocks are silicious, argillaceous, marly or calcareous, and according to hardness and composition are used for various purposes in building, and for pavements, troughs, and filtering stones. Some harden by exposure, and others decay, and vast beds of incoherent sands are found above and under chalks and clays, and of various colours and qualities.

Of the three kinds of sand, sea-sand, river-sand, and pit-sand, the former is the worst, from being so much purged by the action of the waves; river-sand and road-sand are reckoned the best, and pit-sand is found so various in quality as to be incapable of separation or of being recommended for use. Loamy and earthy sands are always beneficial, while many kinds are ferruginous, slaty, and so barren as to effect no improvement on land—and very often they are pernicious.

Sandy soils are managed with infinitely less trouble, and at an expense greatly inferior to what clays require; but at the same time the crops produced on them are generally of much smaller value. In some parts of Britain the surface is little better than a barren waste, wherein no artificial plants will take root; the soil is too loose and crumbling, and never forms a clod, even in the driest weather. A degree of adhesion, after being wet, distinguishes sands and loams, which crumble on every exposure.

In speaking of clay soils, it was recommended that all lands be early ploughed, in order that adhesive soils may derive benefit from the changes and vicissitudes of the weather in producing the essential work of pulverization. It is equally necessary for dry lands to have

an early furrow, in order to acquire consistency and consolidation by lying in a ploughed form during winter, and not being disturbed in the spring till near to seed time. For fallow lands this consideration is of much benefit. The mellow appearance, on being cross-ploughed in the spring, easily distinguishes early from late ploughing,—an appearance retained during the whole summer. All lands, therefore, intended to be fallowed, should be ploughed in December or January of the previous winter; the circumstances of later ploughings having been occasionally found equally beneficial, does not militate against this general rule. In these dry soils, ridges are unnecessary,—and the land generally lying in pieces of ten to twenty yards in breadth, water-furrows or cuts are not required. In this ploughed state the land generally lying till the dry weather in the spring permits the cross-ploughing, after which the land is harrowed, rolled, and ploughed alternately, for two or three times, and all stones and weeds picked by hand and removed. The land is then dunged and sown with turnips.

During the preparation of these dry lands, it would be very advantageous if eight or ten days could be allowed to elapse between each working of the land, in order to allow time to acquire moisture; and the workings should be quickly executed in order to retain it, as long exposure of the soil in dry seasons will dissipate the moisture, on which the safety of the turnip crop so very much depends.

Sandy soils are not adapted for wheat, but produce turnips, oats, and barley, in tolerable perfection. They are well suited for the growth of grasses, and derive much advantage from being pastured for several years.

ROTATIONS FOR SANDY SOILS.

I.—1, Turnips.—2, Barleys or oats.—3, Clover.—4, Pasture.—5, Peas or tares.—6, Oats.

II.—1, Turnips.—2, Barley.—3, Clover.—4, Pasture.—5, Pasture.—6, Oats.—7, Tares.—8, Wheat.

III.—1, Turnips.—2, Barley.—3, Clover.—4, Pasture.—5, Oats.

The grass seeds proper to sandy soils are many of the perennial kinds, as it is found advantageous to keep these lands for two or more years in pasture after a crop of hay.

¼ bushel of rye grass; ¼ bushel of cocksfoot; 4 lbs. of meadow fescue; 4 lbs. of hard fescue; 4 lbs. of meadow catstail; 4 lbs. of crested dogstail; 8 lbs. of red clover; 4 lbs. of white clover.

Sand can act as a manure only as an earthy ingredient, by rendering stiff clay soils more loose and friable, and by entering into their composition, by breaking the coherent texture, and keeping the pores open to the roots of plants. On rough grown meadows and pastures,

an application of sand has sweetened the grass, and produced a much finer herbage; and at the rate of six hundred cart-loads an acre it is said to have effected very great improvements, and in Ireland it has been often mixed with the surface soil, and has produced very great and lasting benefit. It has also been used as litter for cattle, and has been attended with success, after being saturated with the urinary liquid.

In the application of earthy matters as mixtures, a chemical combination of them is beyond human power, and a mechanical mixture will mostly be imperfectly performed, from the difficulty, and in many cases the impossibility, of reducing the ingredients to a state that is proper for reciprocal action, if no marly or calcareous particles exist in the clay or sand, and the roots of plants sustain damage in passing from one mass of heterogeneous substances into another, arising from the want of minute subdivision and mixture. The great quantity of the materials required forms a very weighty objection; but situations are not wanting where the materials are found contiguous, and the application very easy. In such cases, a few trials made on decisive and tangible grounds, would show the eligibility and propriety of the improvement.

Sea-sands and shelly sands are very abundant on the shores of Britain, and differ much in colour and quality, according to the various substances that are mixed together. The latter are chiefly calcareous earths, and often effervesce with an acid; and when found in minute particles they form a manure of great value on all clay soils, heavy loams, and on mossy and spongy lands, and on sour meadows and pastures. Shelly sand occurs more or less mixed with other substances, but in every state it has been found very useful on heavy wet lands, and for mixing in composts to be used on light soils. Sea-sand, with scarcely any perceptible mixture of shells, has proved of much benefit on mossy and clayey grounds; and in many places it is used as litter for cattle from scarcity of straw, and has yielded an excellent manure. An application of sand to wheat fallows has been recommended, and then it should be applied late in the season of working the land, and be slightly covered.

Probably the most economical use of sands, composts, and all top-dressings, consists in their being spread on leys one year before being ploughed, that it may have time to raise a grassy sward, and get fixed on the soil, and incorporated with the surface among the roots and fibres. The decomposition of the grassy sward will afford nutriment to the succeeding crops.

SECTION IV.—Calcareous Soils—Crops suitable to them.

Calcareous soils are distinguished by the property of effervescing in acids, and are confined to the locality of the limestone and chalk formations. When mixed with clay, the soil is wet, spongy, and untractable; when mixed with loam, it forms a soil of middling value,—the former producing medium crops of wheat, beans, and clover, the latter turnips, barley and grasses, in great perfection, and yielding an herbage most peculiarly grateful to sheep.

The wet and inferior calcareous lands are fitted for the rotations and grasses given for the inferior clay lands, and lighter sorts for the rotations and grasses given for sands.

Loamy soils are by far the most numerous class, and also the most valuable to the farmer, as they include the loamy clays, loamy sands, and all soils that possess a fair mixture of that ingredient. Loam or mould is composed of decomposed animal and vegetable matters, is a principal material in soils, and differs greatly according to the quantity and quality of the matter itself, the state of reduction it has reached, and from the manner in which it happens to be incorporated with the constituents of the soil. Such soils are almost universally dry, and possess the happy medium of absorbing, retaining, and giving off moisture in the quantity most suitable to the growth of plants. On these soils are produced every crop or plant of the present day, varied something according to quality and situation. Loamy clays produce potatoes, turnips, and beet, wheat, barley, oats, and clovers; loamy sands and chalks yield turnips, barley, and grasses, in much perfection. They are easily managed, admitting labour at almost any season, and on them manures have the greatest and most lasting effect. Much of the fertility may be ascribed to the quality of the original subjacent formation being favourable to the growth of vegetation, which grew and died upon it, and, with animal remains, produced the quality and depth of the stratum. The property of depth generally bears a direct ratio to the fertility of the soil, or rather, the latter to the former.

Rotations for Loamy Clays.

I.—1, Green crops.—2, Wheat.—3, Clovers.—4, Oats.—5, Winter tares.—6, Wheat.

II.—1, Green crops, turnips, potatoes, and beet.—2, Wheat.—3, Clovers.—4, Oats.

III.—1, Green crops.—2, Barley.—3, Clover.—4, Wheat.——And: 5, Cabbages or beet-root.—6, Oats.—7, Tares or peas.—8, Barley.—9, Beans.—10, Wheat.

IV.—1, Turnips or cabbages.—2, Barley.—3, Clovers or tares.—4, Wheat.—5, Potatoes and beet.—6, Barley.—7, Clover.—8, Oats or wheat.

V.—1, Beet and potatoes.—2, Oats.—3, Clovers.—4, Wheat.—5, Turnips and cabbages.—6, Barley.—7, Beans, and tares.—8, Wheat.

VI.—1, Green crops.—2, Wheat.—3, Beans, peas, or tares.—4, Barley.—5, Clovers.—6, Oats.

VII.—1, Green Crops.—2, Barley or wheat.—3, Clover.—4, Oats.—5, Vetches.—6, Wheat.

VIII.—1, Green crops.—2, Barley.—3, Grass seeds.—4, Peas or tares.—5, Wheat or oats.

These rotations apply to lands of the first quality.

ROTATIONS FOR INFERIOR LOAMS.

I.—1, Green crops.—2, Barley.—3, Clover.—4, Grass.—5, Beans, peas, or tares.—6, Oats.

II.—1, Turnips.—2, Barley.—3, Clover.—4, Pasture.—5, Pasture.—6, Oats.—7, Tares.—8, Wheat.

III.—1, Turnips.—2, Oats or barley.—3, Clover.—4, Pasture.—5, Oats.

The grasses for the best clayey loams usually for one year as a crop of hay.

PER ACRE.—1 bushel of rye grass; 16 lbs. of red clover; 4 lbs. of white clover.——Or. ½ bushel of rye grass; ½ bushel of cocksfoot; 4 lbs. of meadow fescue; 4 lbs. of meadow catstail; 10 lbs. of red clover, 4 lbs. of white clover.

On inferior loams, the seeds sown are of a more permanent nature:—

1 peck of rye-grass; 1 peck of cocksfoot; 4 lbs. of meadow fescue; 4 lbs. of meadow catstail; 4 lbs. of poa trivialis; 4 lbs. of poa pratensis; 8 lbs. of red clover; 4 lbs. of white clover.

Gravelly soils are very open and porous in their nature, and imbibe and give off moisture with great facility, and from this latter property they are apt to burn in dry seasons. Gravels are mostly composed of small stones, in some cases argillaceous or flinty, and in others calcareous or chalky. The soils are of easy cultivation, and are soon brought into the proper state, and produce turnips, barley, and grasses, in high perfection.

The rotations used, and the grasses sown on gravelly soils are the same as on sands and inferior loams.

In the working of all turnip lands and the more friable clays one process of the operation of the grubber is much more useful than two or three ploughings, both for the purpose of raising the roots of weeds, and in pulverizing the soil. The round or triangular tines carry along without tearing or cutting the couchy roots, and the points of the tines being bent forwards, raise and break the soil to a very considerable depth. It was first used in East Lothian, and is now used extensively in all parts of the country, and with great benefit. In that county the turnip soils are clayey loams, and the wheat lands are friable clays, and both kinds of soil admit the use of the grubber now mentioned, in the largest extent.

The first furrow, or the winter ploughing, must be given as usual, and as deep as the humified stratum of the soil will allow. In the spring, the grubber works across the furrows, and then lengthwise, when the harrow and the roll will be used in the common way. After each gathering of the weeds, the grubbing is repeated till the land be cleaned, and the soil pulverized, and ready for being sown.

It is very evident that this mode of preparing turnip land will retain the moisture much more closely than by ploughing, which in each process turns up and exposes the under soil, which has gathered moisture by being hidden from exposure. In dry seasons, the whole depth of the moved stratum is completely dried up, and becomes wholly devoid of moisture, on which the success of turnip farming so very much depends. The Scotch mode of drilling, or forming the land into ridgelets, is very objectionable, by exposing the land so often to scorching suns in the arid soils of south Britain, in the process of working and drilling; and sowing the turnips on the flat surface is preferable. The grubber now mentioned moves and works the soil, and catches and raises the roots of weeds, without turning up and exposing the land to sun and drought; a close surface is presented by the harrowing and rolling, and which is of incaculable advantage in guarding against the evaporation of moisture.

SECTION V.—Peat-moss—How Formed—How Reclaimed—Crops Suitable for Reclaimed Peat-moss—Peat as a Manure.

Moss or Peat is generally thought to have been formed by the decomposition of a vast number of trees, leaves, and fruits, assisted by the decay of aquatic plants, and by the earthy matters carried by rains and floods to the places of formation. This theory of its formation is very inconclusive, though in some particular cases it may account for some few appearances, while for others it certainly offers no satisfactory conclusion. Peat-moss is also reckoned an original formation, and of antediluvian origin; others think it a growing vegetable, which by its decay causes the increase of the substance, and may ultimately cover the earth; and the more general opinion ascribes it to the collection and decomposition of ligneous and aquatic vegetables brought together by the destruction of forests, by wars, by the axe, and by tempests, and accumulated by the decay of these bodies, and of the plants encouraged by their decomposition. It occurs in the northern parts of Britain, in Scotland and in Ireland, in beds of great extent, varying in depth from four to twenty feet.

When dried peat is examined, it is found to consist of roots and fibres in every stage of decomposition, from the natural wood to the completely black vegetable mould. From the nature of its formation under the surface of water, it acquires a portion of tannin, which has the property of preserving animal and vegetable matter from decomposition. Peat contains all the elements of the richest manure, and may by an easy process be converted into humus: for this purpose the agency of alkalies is the most effectual. If the tannin be decomposed, that of the vegetable fibre will go on, and soluble humus will be formed. When peat is newly dug up, if caustic lime be added to it before it is dry, the moisture of the peat slakes the lime, which acts on the gallic acid in the peat and neutralizes it. If this mixture be then excited to fermentation by the addition of animal matter, such as urine or dung, oxygen is absorbed and carbonic acid evolved; and the residue is converted into an excellent manure, containing much soluble humus. The same may be effected more slowly by mixing peat with clay or marl, and allowing the mixture to remain exposed to the atmosphere for a considerable time, frequently turning it. But nothing accelerates this process like the addition of putrescent animal matter, which acts as a ferment, and greatly hastens the decomposition.

The soils for which peat forms the best manure are the chalky and clayey soils. Sand has too little tenacity; it lets the gases produced by the decomposition escape, instead of attracting them, as clay and chalk do, and preventing their escape.

The burning of peat destroys the vegetable matter, and leaves the earths and salts behind. They are, accordingly, very strong stimulants to vegetation, especially that of clovers and herbaceous plants, of which the leaves and stems are the most valuable parts. If the soil is well furnished with vegetable matter, and capable of bringing an abundance of seed to perfection, it may be very useful to apply stimulating manures, such as peat ashes, to increase the verdure; but on poor soils, destitute of humus, the increase of the stems and leaves does not ensure a proportionate increase of seed. Hence it is often remarked, that soot, potash, saltpetre, and similar substances, produce a deceitful growth, giving a rank green leaf, which is not succeeded by a heavy ear; but, on the contrary, the produce in seed is rather diminished than increased by the use of the manure. Whenever a stimulating manure is used, the soil should be naturally rich, or enriching manure should be applied at the same time.

The effects of ashes are great on clovers and sainfoins, and on all dry chalks and dry hot sands. Moist weather is necessary for the

development of their effects, and it is probable that the want of success in certain cases may have arisen from unfavourable circumstances, as the ashes of any substances contain the essential elements of vegetation, when not counteracted by contingencies in the application. The very great bulk of materials that is required to yield a quantity of ashes, and the weight of moss as a body for conveyance, and the cost of the manufacture of it into ashes, have led to the almost total neglect of it, although its great value and utility be sufficiently proved.

In order to correct the acidity of moss, it has been recommended to mix it well with farm yard dung, and to add a quantity of slaked lime in the ratio of five to six of moss and also to pour urine and leys on the moss, and then mix it with the dung and lime. The acid is supposed to be banished or neutralized by this process, the fermentation effected, the oil dissolved, and the putrefaction hastened. A hundred pounds of potash are sufficient to saturate moss for an acre of land, by being dissolved in boiling water, at the rate of half a pound to a gallon, and poured on the moss, broken small, in layers: when fully saturated it may be turned over, after lying some weeks, and a quantity of lime may be added, when the heap will be reduced to a fine compost. Lime and chalk are recommended, in order to reduce moss by putrescence; but the results are not satisfactory—the elements of fermentation and of putrefaction are not present, and no active combinations ensue. The total absence of any approximation to the putrid decomposition in moss, prevents the generation of the aeriform fluids that form the new combinations of matter; and no residual substances are produced either in a putrefying or putrid state, which are so well known to be the most powerful promoters of vegetation. Peat consolidates into hard lumps by exposure; and even after being used in a soft state, mixed with other substances, it is often found in curdled particles, and gradually disappears without forming any combinations, or entering into any affinity with any of the substances with which it has been brought into contact, in the soil, or in the compost heap. Through all the formations of moss there prevails a weakness of cohesion and of consistence, which renders it unfit for any extensive or beneficial application, and it moulders and disappears without action or energy of any kind. It has been satisfactorily proved, that moss contains in itself no fertilizing properties, though by being turned into charcoal and brought into contact with other bodies, it is said to become a powerful manure. Lime forms no useful combinations with moss—the resistance to putrefaction is great—in fact, it may be doubted if it can be made to pass through that process: a

breaking and crumbling of the particles may be effected, but it is a reduction very different from putrid decomposition. When moss gets hardened, it will refuse admission to any body, even to water itself. The mode of using moss, by reducing it to ashes, and sowing them as a manure for turnips by the drop drill, or spreading them as a top-dressing on grasses and clovers, is much the safest and most economical process of deriving any benefit from it.

The specific gravity of soils is in all cases an indication of the organized matter it contains: for such matter is more abundant in the lighter soils. Argillaceous soil is light and hard to the touch, and, when rubbed on glass, scratches it. A red or yellow colour denotes a ferruginous soil, while softness generally denotes one of a calcareous nature.

The power of absorbing and retaining heat and moisture, is intimately connected with the fertility of soils. Stiff clay is heated with difficulty; but, containing less moisture, the warmth is not so easily expelled. A black soil which contains soft vegetable matter, is the most freely heated by the sun and air. Deeply coloured soils acquire a higher temperature than those of a paler complexion.

The power of retaining heat is much affected and modified by the property of retaining moisture, and this latter quality depends in a great measure on the degree of the comminution of the parts; for the more divided the soil, the greater is the power of absorbing. This property is greater in vegetable than in animal bodies, and the last have a greater power than compound earths, and there is a great diversity of power in the earths themselves. Fertility very much depends on this power of drawing moisture from the atmosphere, and by situation in a high or low latitude—by a favourable aspect or exposure, and by the quantity of rain that falls on them—on the heat and humidity of the atmosphere, and on the quantity and quality of the exhalations with which it is charged, and probably more in many cases, on these circumstances now mentioned, than on the nature of the soil itself. These external circumstances are often so powerful as to overbalance the constitutional quality, and, in many cases, they correct constitutional defects; and soils similarly situated differ much in fertility, and consequently the similar constituents of original formation are not by any means admissible as a universal rule of judgment.

Experience has now fully established the fact, that, in a proper rotation of crops, a plant with a naked stem and farinaceous seed, should follow one with a branched stem and fleshy root, which has been taken from the ground without bearing seed; and if all these

conditions cannot be obtained, that some of them at least must be complied with. Wheat sown after clover (which is allowed to be the best succession on light soils) fulfils all the conditions; when it is sown after beans, the condition of the preceding crop not ripening its seed, is given up; and, consequently, this succession is inferior to the other. It is not possible, however judiciously the land may be manured, to raise the same crop in regular succession without loss and detriment, both to the land and in the quantity of the crops themselves. Wheat and clover answer well in alternation, but not singly; and this shows that the same effect is not produced in the soil by these two crops. Experiments have been made by very eminent chemists, particularly by Macaire of Geneva, at the request of Decandolle, the celebrated botanist, which leads us to suppose, that, in the formation of the seed, or other nutritious parts of plants, the sap is digested; that it takes up certain elements and deposits others, which are the residue of the process; and these, being no longer necessary for the formation of the seed, are rejected by the vital action of the plant, and exude by the roots. Thus certain inferior animals, which, in many respects, have some analogy with vegetables in their growth, as the Polypi, take in nourishment by the same openings or pores by which the excrements are voided after digestion; and the different constitution of different animals enables one class to feed on the excrements of another: whereas no animal, in a healty state, can derive nourishment from that which it has already digested and voided. Our ignorance of the functions of vegetable life prevents us from seeing the effects produced on the sap, by the expansion of the blossom or the ripening of the seed; but experience leads us to the conclusion that certain plants thrive best after certain others; and that, in this case, they are always of distinct and different natures, and of different natural botanic families. Macaire, and some other scientific men, observed the change that took place in the water, in which wheat had been made to grow. They found a deposit in the water, of the nature of bitter extract, and this they concluded to be excrementitious. Beans grow well in this water; and, on the other hand, wheat throve in the water in which beans had grown. The effect of fallowing land has been explained on the same principle; the excrement is washed out by the rains, or is decomposed by the light and air, to which it is exposed by the repeated ploughings. Thus the land is said to be sweetened, an expression very common among farmers engaged in fallowing. It is highly important to the practical farmer that the chemical principles, as well as the practice and the experience on

which the practice is founded, should be understood. This can only be attained by an analysis of the soils in which the various crops are grown, and by experiments similar to that of Boussingault, (given at page 26,) of the ashes of the crops themselves. By such a course of investigation the practical farmer will learn by experience and test his experience by the truths of science as to the rotation of crops which succeed best, and how soon the same kind of seed may be sown again in the same ground, with the reasonable prospect of its producing a good crop, which can only be learned from actual experiment and observation.

Within a few years past, an attempt has been made, and yet continues, to convert peat into a manure by means of the substance being turned into a charcoal, or an impure carbon. Immediately after being dug, the mass is triturated under revolving edge wheels, faced with iron plates perforated all over the surface, and is forced by the pressure through these apertures, till it becomes a species of pulp, which is freed from the greater part of its moisture by a hydraulic press. It is then dried, and converted into coke or charred coal. Or peat may be made into charcoal in the common way of wood,—a process which is well known.

During the operation of charring, the more volatile elements are expelled, and the carbon or the fixed ingredient remains, with some saline matter, which renders it impure. Charcoal is absolutely infusible, and a very bad conductor of heat; but it is a conductor of electricity. It is black, lighter than water, and full of pores, occasioned by the expulsion of the bodies volatilized. Like other porous substances, it has the power of condensing gaseous bodies, and to a greater degree than most, or perhaps any other substances. Saussure found that charcoal absorbed ninety times its volume of ammoniacal gas, which is known as a very powerful promoter of vegetation. Burnt clay is thought to operate in the same way by fixing the ammonia. Charcoal, when heated, yields the greater part of the condensed gases.

Peat charcoal requires to be reduced to powder by rollers, and is sown in drills for green crops, or on young vegetables in broadcast. The antiseptic quality will prevent any benefit accruing from decomposition, and the connection of the condensed gases will impart the quality of its use. Most manures consist in the ultimate elements of matters, or the last residue of destroyed substances. Charcoal cannot possess these qualities, for it is the result of a stifled process, which advances a stage, but does not reach the termination of the intended destruction. The charcoal may retain some part of the heat of the

smouldered combustion, and impart a warmth to the tender roots of the plants, or it may by that agency stimulate some body in the soil to communicate an energy from a latent property, till then dormant.

Peat charcoal is reckoned a deodorizer. It absorbs the noxious effluvia of putrid or decaying substances, which offend by their smell. A strong smell is not thought to be a fault in manures, but if the charcoal be mixed with or laid upon night soil for instance, the gases will be retained and conveyed to the ground instead of being allowed to escape. In this way peat charcoal may prove of considerable benefit.

The preparation of peat charcoal is included in the prospectus of a company that prepares manures by a special contract, But much time and caution are yet required to sanction the use of charcoal as a manure.

CHAPTER III.

MANURES.

MANURES are naturally divided into three classes,—the animal, the vegetable, and the mineral. The first division comprehends those substances that are derived from animals, either in the shape of excrements or from their dead bodies; the second includes the vegetables so applied, either singly or mixed; and the third contains the minerals, fossils, earths, or earthy substances, used in the original state, or mixed with other materials. Mixed manures may be placed under some one of those heads, without making another division; and the most abundant of the substances that are used, commonly called "farm-yard dung," may be treated as an animal manure, though it be a mixture of animal and vegetable matters, and, properly, a compound article. With it we commence the description.

SECTION I.—FARM-YARD DUNG—COW'S DUNG—CONTENTS OF THE ASHES OF STRAW—PREPARATION—APPLICATION OF FARM-YARD DUNG—DRILLING THE LAND, AND COVERING IT FOR TURNIPS; FOR POTATOES; FOR BEET; ON CLAY SUMMER FALLOWS; ON GRASS LANDS—QUANTITY TO EACH PURPOSE—FORMATION OF HEAPS.

"FARM-YARD DUNG" is composed of the culms or straws of the different grains that are used for food and litter, and the excrements

of the domestic animals, the horse and the dog, the ox and the cow, and the poultry-yard. The quantity of excrements voided by an animal depends on the kind and quantity of the food it eats; all liquefied and juicy substances very much increase the fluid secretions, and also the putrified residuum. The quality of the dung depends also on the quality of the article consumed as food, but much more on the peculiar construction of the digestive organs of the animal: for the same kind of food given to animals of a different genus, will yield an excrement of a very different quality, and even when given to those of the same species, and under the same treatment, a great difference will often be found, which can only be attributed to the construction and action of the constitutional organs. The alterations, combinations, and decompositions which food undergoes in the stomach of animals, in affording nourishment to all the different constituent parts, is somewhat similar to the growth of plants,—of both processes, however, we are in a great measure ignorant. The dung of swine is of a [illegible], inclining to form a saponaceous mass, and constitutes a manure of great power and duration. The dung of cattle contains matter soluble in water, and gives in fermentation nearly the same products as vegetables, absorbing oxygen, and producing carbonic acid gas. The insoluble part seems to be mere woody fibre, and analogous to the residuum of the vegetables that constitute their food, after being deprived of all the soluble materials. The process of rumination, and the additional chewing which the food undergoes, imparts a richness of quality to the juices of the saliva. Cow's dung, fresh, contains.—

Lime,	12·	Alumina, with some Manganese,	14·
Phosphate of Lime,	12·5	Silex,	52·
Magnesia,	2·	Chloride of Potassium, and Sulphate of Potassa,	2·5
Iron,	5·		
			100·0
Specific gravity,			1·045

The stalks of wheat, barley, oats, rye, peas, and beans, with occasional mixtures of the haulm of vetches, and of refuse of hay, being mixed with the fæces of the animals, or the debris of their food, much augment the bulk, and materially affect the quality of farm-yard manure. The constituent parts of those substances, as shown by chemical analysis, are principally earths, and soluble earthy salts, and in different proportions, which, by entering into combinations with the animal and more easily soluble matters in the dung, retard the too rapid putrefaction of those substances, and constitute, with proper

mixture and preparation, by far the most efficacious and durable fertilizers yet known. The mixture is more or less saturated with the urine of the animals; and this fluid supplies ammonia and other constituents, which add to the fertilizing power. The great value arises from containing both animal and vegetable substances; the former abounding with molecules of the body itself from fatty matters; the latter yielding an aliment to plants, and restoring to the soil the very ingredients withdrawn from it in the previous year's crops.

M. de Saussure made an analysis of the ashes of some plants, of which the following table presents a view.—

100 Parts Ashes Contain	Horse Chestnut, ripe.	Beans.	Wheat Straw	Wheat Bran.	Wheat grain.	Stalk of Maize	Seed of Maize	Barley Straw	Barley Grain.	Bean Blossom.	Bean Straw.
Potash	51·	22·45	12·5	14	15	59	14·	16	18·	57·21	31·
Phosphate of lime .	28·	63·93	5	30	32	9·7	47·5	—	9·2	Carbonate.	—
Chloride of potassium	3·	0·9	3·	0·16	0·16	0·52	0·25	0·5	0·25	12	14
Sulphate of potash	—	2	2·	—	-	1·25	0·25	3·5	1·5	12	2
Earthy phosphates .	12	27·92	6·2	46·5	44·5	5	36	77	32·5	18	6·
——— carbonates	—	—	1	—	—	1	—	13·5	—	5	37·5
Silica . . .	0·5	—	61·5	0·5	0·5	18	1	57·	35·5	2·	2·75
Metallic oxides . .	0·25	0·5	1·	0·25	0·25	0·5	0·12	0·5	0·5	0·5	0·57
Loss	0·25	2·3	7·8	7·50	7·59	8·59	3	0·88	2·8	2·8	0·25

The straws of barley and oats differ little from that of wheat; peas and vetches contain more soluble salts, and less of silica.

Cattle are tied in stalls, or they roam at large in yards· in the former case, the excrements and litter, in a mixed state, are carried daily to the open yard, and should be spread evenly and thinly over the space; in the latter case, the yard must be regularly littered, the feeding cribs constantly moved, that the quality of the dung may be uniform. Constant attention is required, that the yard be kept level, and that it be regularly and thinly littered, and that all different substances be well mixed and moistened with the urine. The dung of pigs is well to be mixed with that of horses, that the different qualities may correct each other, and the "fire-fanging" of the latter be prevented. In order to effect this purpose, the stables and piggery should adjoin one yard or two, where the dung from each can be regularly and thinly spread, and be mixed in the proper way.

When the yards are filled to a height that renders any further accumulation inconvenient, the whole mass is carted during wet weather, if men and horses can work, to a convenient dry corner of the field where it is to be applied. The heap should be of a square form,

with sloping sides, and raised to a height not exceeding six feet, composed of separate banks of four feet in breadth, and extending regularly the whole length of the heap, to which banks the carts are run close backwards, and the dung pulled from the carts and spread regularly and thinly by persons appointed for that purpose. If the dung come from the yards in a rough or dry state, such loads must be spread rather thinly on the banks, and mixed with moister substances, that an equal putrefaction may ensue; and care must be taken that no lumps lie unbroken, but be well shaken out and mixed. A heap treated in this manner, will be in a good state for application without any turning over and mixing. When the dung comes from the yard in a proper moist state, if it be dry and rough, or if less pains be bestowed in building the heap, a turning over will be necessary, when all lumps must be broken, and the dry and moist parts carefully mixed. So soon as the building of a heap is finished, a layer of earth should be laid round the edges on the top, to prevent drying, and the situation should be sheltered, if possible, from the scorching sun and drying winds. The liquid oozings may be gathered to a point by means of a trench cut round the heap, and thrown occasionally over it, and the liquids may be brought from the farm-yard for the same purpose; when the sides and top get dried by exposure, they must be cut down and thrown on the top, which will be turned over, broken, and mixed, in order to obtain every possible uniformity of quality in the heap. In large fields, two or three heaps may be required for convenience of shorter carriage, and those must be so placed as to cause no interruption to the process of regular application.

The dung being prepared in heaps in the field, and the land having been brought into a proper state of tilth by previous ploughings, harrowings, and rollings, and every weed and stone having been removed, a straight furrow is drawn, by the common plough, in the direction in which it is wished the drills should lie—if on wet-bottomed lands, the descent of the water should be studied; if on dry soils, the drills may be drawn diagonally, or across the direction of the ridging for the subsequent barley crop. The drilling should commence in the afternoon previous to the morning when the dunging of the land and sowing of turnips is intended to be begun—that the drilling ploughs may be advanced so far before the dunging process as to afford constant employment, and, at the same time, not to expose for more than half-an-hour the newly made drills to the influence of evaporation. In the largest single arrangement, two ploughs open drills at the rate of eight acres a-day; four or five one-horse carts will

bring forward the dung, according to the distance, four men filling the carts at the dung-heap, one man to pull the dung from the carts into regular heaps for three drills, two boys to drive the carts to and from the heap, and another to lead the unloading cart steadily along the drills, four stout lads or women to spread the dung close behind the carts, and a very careful man with them to see that the dung be properly distributed—three ploughs covering the dung with two furrows to a drill, or finishing a drill at once round the field; and the two-drill turnip-seed sower depositing the seed immediately, as the plough finishes the drill. The ploughs are provided with light main-trees, of five or six feet in length, which reach across two drills, and enable the opening ploughs to move exactly in the centre between the drills, and thus give the ploughman an open sight before him. In covering the dung, the right hand horse walks in the furrow: the horse on the left walks on the top of a drill, leaving a drill between them, which drill the plough splits in moving along, and throws a heavy furrow of fresh soil over the dung. At the end of the field the ploughs turn to the right, and, in returning, the horses walk in the furrows, with the plough in the intervening one, and the plough throws another furrow of fresh soil over the dung from the opposite side. The main-trees stretch the breadth at which the horses walk from each other, the mould-board of the plough exactly fills the furrow, and the horse, by walking on the top of the drill, does not disturb with his feet or tread upon the dung spread in the furrows. The ploughs regularly follow each other, the right hand horse walking in the furrow made by the plough immediately preceding, and the left hand horse following the same plough in returning.

In such closely-confined arrangements of force, devised for the purpose of producing a certain result by a number of simultaneous operations, much skill and dexterity are required, and the quantity of each exerted by the farmer in his operations, marks the degree of eminence he has acquired in his profession. At that hot and dry season of the year, the dung and the land must be exposed as little as possible—hence the necessity of dispatch when the proper moment arrives. The opening ploughs should afford few, or no more drills than just to give full employment to the carts; the spreaders must be close behind them, and the covering ploughs should enter on every three drills as soon as the dung is spread, and in no case should they be more than once round the field behind them. At night the whole process ceases at once from the closeness of the arrangement, every drill of dung is covered, none is carted out and left unspread, every

finished drill is sown with seed, and the opening ploughs may have about six drills done to afford a ready beginning to the dung carts next morning. Not more than half an-hour should elapse from opening the drills to the covering of the dung and sowing the seed, and, in that half-hour, the dung is moved from the heap, deposited, and covered. The strength of the different parts of the force must be so adjusted that one part does not press on the other, and have not full employment, and another part, by having too much to do, be distressed and lose ground. In every department of active operations, combination of force has a magical effect on the spirits of the labourers themselves, and wherever animate power is to be applied, it should, if possible, be moved in masses, proportioned to the result that is contemplated; and must be directed by a person thoroughly acquainted with the details of the operations, and who has the skill to plan, and the energy to execute. Such arrangements for dispatch are more necessary in some cases than in others, owing to natural causes: it is most particularly required in turnip sowing, from the urgent and imperious necessity of retaining moisture in land and dung, to promote the germination and growth of the tender plant. By the above arrangement eight acres will be finished in a day, and will suit farms of 400 to 600 acres; on larger extents the force may be arranged in two divisions, which proceed in the manner above described. On smaller farms, one plough to open drills and two to cover the dung will finish from four to five acres daily, and on smaller still, two ploughs would open and cover about three acres of drills; and one plough, with some exertion, morning and evening, might finish about two acres, with two carts to bring forward the manure.

On sands and sandy loams, turnip-drills are opened and the dung covered by a double mould-board plough, which performs the work more expeditiously than the common plough, and, in the case of light and loose soils, as effectually; but on all stiff-bottomed lands, which constitute the best part of turnip lands, the preference is now very justly given to the common plough. The narrow angular share can penetrate deeper than the two-winged one, and raises more fresh soil, on which the safety of the turnip crop so very much depends; on stiff bottoms the broad and two-winged mould-board of the other throws it upward, and the covering of the dung consists in the dry cloddy surface left by the harrow and the roll, and pressed together over the drills by the extreme upper part of the mould-board. The common plough is also employed in opening and covering drills with one furrow on light lands, and answers the purpose very well, pro-

vided the soil be of a depth to afford a heavy furrow: and, in all cases, the common plough possesses the advantage over the double-winged, of going deeper into the land and raising more fresh soil, an object of the very last importance in turnip farming. The old method of drilling, by going twice with the common plough in one furrow, is the most effectual way on stiff lands, but the longer time required now sets it aside, and the common plough, with one furrow, when well directed, and on lands well prepared, will make a sufficient furrow for the dung, and, by covering the manure by two furrows, fresh soil is raised over the dung, where the seed is immediately sown. In damp seasons, and in showery weather, and on fine soils that are full of moisture, the rolling of the turnip-drills, may be light, and, in many cases, it may be wholly dispensed with, as the hardening of the surface would much damage the tender plant. But in dry seasons, and more especially on clayey loams, where the surface of the land will be cloddy despite every operation of the harrow and the roll, a heavy pressure on the drills is essentially necessary immediately after the seed is sown, for the purpose of squeezing the cloddy surface to some degree of pulverization for a seed-bed near to the dung, and to present a closer and a more impenetrable surface to the influence of drought. These crumbling soils produce good crops of turnips, but are difficult of management; the seed is usually sown amongst the clods, with very little moisture, which is soon exhaled, and it lies there exposed to the scorching heats, and in many cases never vegetates. Heavy rolling is the only remedy; of which operation farmers in general are much too sparing, from a dread of creating too much firmness in the land. Cases will certainly occur in moist seasons when the roll should not be introduced, except very lightly, on any lands, occasions which no practical man can be at a loss to determine.

Putrescent manure, lifted fresh from the yards, is almost universally applied to potatoes, as that root, from the greater bulk and strength of the sets, does not require so nice a preparation as the small and delicate seed of the turnip. Drills are opened for potatoes at the distance of thirty inches—a wider distance not affording, by experiment, any increase of produce, and a narrower space not allowing the scuffling and earthing ploughs to work and move freely and effectually, or room to the roots to expand and multiply. The dung is laid in the drills and spread as for turnips; the sets of the plant are deposited at the distance of eight to twelve inches from each other, on the top of the dung; the drills are then reversed, the left-hand horse always walking on the top of the drill, so as not to disturb with

his feet either the dung or the potato sets. The arrangement of the force is the same as in turnip-sowing. The potato sets being covered by reversing the drills, a light roll is applied to flatten and consolidate them, and in some places a harrowing is given to loosen the soil and check the weeds, just as the plants are beginning to appear above the ground. But if land be properly farmed, there will be few or no perennial weeds in the soil, and a small plough and a scuffler with knives, alternately and repeatedly applied, together with an early hand-hoeing, will more effectually check and remove the crop of annual weeds that in some soils and situations almost defy eradication. Though almost universal practice does not allow any preparation of dung for potatoes, it may, nevertheless, be very reasonably supposed, that if the mass was laid into a proper heap in the field, and a heat and a partial decomposition produced, very considerable advantages would be derived from the progress of an incipient fermentation, and it is essentially necessary that the dung be in a moist, or rather, in a very wet state. Potatoes delight in moist soils, and in humid climates; and clay soils and heavy loams will admit the manure being applied in a drier state; but much moisture should be used, if possible, on all dry soils, and in wet seasons, the plant being of a very succulent nature, and the sets being apt to mould and spoil by dry rot when not supplied with moisture to support the juicy state. On dry lands, and in dry seasons, the dung cannot be too wet.

Farm-yard dung is applied to the raising of beet-root or mangel wurzel, in a similar way as for potatoes, the seeds being sown by a machine on the top of the dung, or dibbled by hand. It is also spread on the surface of the land, ploughed in by one furrow; and turnip-seed is sown broadcast by hand. In the application of dung to the raising of green crops during the dry season of the year, the utmost dispatch must be used that is consistent with the proper execution of the work; the different operations must be simultaneous and in close order, in order that the main object, the depositing of the seed in a proper bed of fresh or newly stirred earth, may be secured under the most favourable circumstances possible. Much will depend on the farmer or other person who is in the charge of the farm; experience acquired, either in primary or subordinate stations, and well improved and matured by observation and reflection, will be very particularly required, and are absolutely necessary in such occupations, especially on large establishments, where the employment will not be a sinecure; and, if properly executed, it will exceed in value, the work of any single plough on the farm.

The oldest application of farm-yard dung is on summer fallows for wheat, on lands reduced during summer to the best state possible, by ploughing, harrowing, and rolling. The dung is carted from the heap or from the homestead, laid in heaps on the land, and spread evenly over the surface, and immediately covered by the plough. The carting of the dung, the spreading of it, and the ploughing must go on in close order, by regulating the number of carts employed, and by the distance of carriage. This application may take place in August with the last summer furrow, which is followed by the seed-furrow in October. In some places the dung is applied with the seed-furrow, but that method requires the drier lands and other favourable circumstances. No preparation is reckoned necessary for dung to be applied to fallows, and it is accordingly lifted from the yard when wanted, and applied, too often, in a very rough state and in a very negligent manner. In many cases dung has been laid in heaps on the field some time previous to application, but a very great loss of bulk ensues; and, as the wheat plant does not require, at that time, so quick and effective support as green crops, the quantity of dung that can be applied is more an object of attention than the quality, as the dung has much time to rot and mingle with the soil by the commencement of the spring vegetation.

Farmers who entertain nice ideas on the subject of the loss supposed to be sustained from the exposing of dung to the influence of evaporation, appoint a lad to follow each plough, to throw into the furrow any lump of dung that is pushed aside by the plough, and lies on the top of the furrow, or remains uncovered; and, on the same principle, drilling has been employed to cover the dung more effectually. By this method, the common plough opens drills with one furrow, in which the dung is laid and spread as for green crops; the ploughs turn round the space occupied by the carts laying on the dung, and, in returning, cover a drill, thus opening and reversing on each side of the carts. Nicety not being required, as if a crop were to be sown immediately, the process is quick; the drills are readily made and reversed on the dung with a light furrow; it is cheaper than ploughing, but it may require a cross harrowing to level the drills, previous to the seed furrow being given. Dry or partially wetted straw applied to fallows will become, by the action of air and water, a good manure before spring; and it may be inferred, that dung would be profitably applied to wheat, as a top-dressing, at that season. It has been proposed to lay farm-yard dung on clovers, leys, and stubbles, that are intended to bear a crop of corn before being fallowed

for turnips, and to sow the latter plant without any manuring. The ground would be thoroughly incorporated by this method, and the labour in preparation would be saved; but much of the strength of the manure would be wasted, and its efficacy impaired, before the green crop comes into contact with it. But the suggestion is worth a fair trial.

Different times of the year have been recommended as the most suitable for applying dung to grass lands,—autumn, winter, and spring. Each season has its advocates; but an application in the spring, so soon as circumstances permit, would seem to afford the readiest support to vegetation. No preparation of the dung is required; it is carted to the fields, fresh from the yards, laid in heaps, spread evenly over the surface, and broken with much care; and when dried by the sun and wind, the field is brush-harrowed, every kind of rubbish is gathered and carted away, and the process is finished by the application of a heavy roll. It is recommended to scratch and tear the surface with harrows before laying on the dung. But it does not appear that any very striking advantage was ever gained by the process. In ordinary cases, fifteen loads of a two-horse cart, and about twenty of small carts, are calculated for an acre of green crops, and twelve of the former to an acre of wheat fallows. Three tons of manure are reckoned to be made from a ton of straw, of which one and a-half tons may grow on an acre; and hence about four tons of rotten dung are got from an acre of land; and this latter figure multiplied by the number of years in the rotation of cropping, usually gives the number of tons applied at one time.

Farm-yard dung is superior in its effects to any fertilizing substance yet known. Some may be equally quick in effect, but none are so lasting. And this superiority may arise from the decomposition leaving an earthy residuum, which adds to the staple of the soil, while the other properties it possesses, produce the usual effects of quick manures. The presence of the materials on the farm constitutes a mighty advantage, as no expense of carriage is incurred; and the greater quantity of produce of any kind the farmer can raise, yields him, in return, a greater bulk of manure for the succeeding crops. In every situation, no opportunity should be neglected of purchasing the materials of this manure, and also the substances when reduced to the form of dung; and when it is got in many different substances, it must be very carefully mixed, and made as equal as possible in quality.

We know enough of the nature of the food of plants to suppose that it must be in a state of solution and suspension, proceeding from minute subdivision; that water is the vehicle, and that the substances

which the plants imbibe must be in a very comminuted state to be capable of being suspended in the common carrier. Similar observations have led to the preparing and cooking of food for animals and human beings; and though plants cannot show us so quickly and visibly, we may very reasonably suppose that they possess the instinctive faculty of choosing and rejecting; and we have this exposition made by them, of their growing more rapidly when fed with one substance than with another, to direct and guide us in the application of aliments to vegetables, as well as to the individual members of the animal kingdom. In the operations of art we must imitate the processes of nature: rankness and coarseness of food produce an unwholesome vegetation, as is seen from excrements dropped on a grass field; and the effects of coarse and unprepared food are well known, on the forms of man and other animals in producing large bloated carcasses. A mass of dung, cold or warm, lying in a drill, must be in too gross a form to present and afford ready and palatable aliment to the tender fibres of plants, and a further reduction and mixing is necessary to produce that matrix of comminuted and finely blended substances in which plants so very much delight to grow. The influence of air and moisture will reduce dry substances to a manure by blending with the soil. Much time, however, is required, and a great quantity of moisture, and the frequent stirring of the land. It is reasonable to suppose that farm-yard dung, and all substances that are applied to land as a manure, should be in a reduced state; and in the case of the former it would require an application to the land at an early season, that it may be broken and mixed by the subsequent workings of the lands by the implements.

In dry land and early climates, the land may be fully half prepared during the previous autumn, and the spring stirrings may be done in the month of May. The farm-yard dung may then be laid on the surface in broadcast, spread very evenly, and ploughed under with one furrow. Finlayson's harrow may then work twice, lengthwise and across, or more if necessary, which will mix the soil and the dung, and make the land fit for being sown, in the form of drills, or on the flat surface in ridges. In order to facilitate the mixing of the soil and the dung as intimately as possible, the straw for litter must be cut by the thrashing machinery into lengths of four inches at most, which will not entangle the implements in the process of working the land. The dung will be carried to the field from the yards without undergoing any heating preparation to produce the gaseous elements. This mode of applying farm-yard dung is in direct opposition to the present

most approved modes, where the putrefaction of the substances, the generation of heat, and the evolution of the gaseous fluids are supposed to be in operation, but it is not without its prototype in nature.

A full century has elapsed since Jethro Tull published the idea of pulverization of the soil being made to supersede the use of dung; and though experience has overturned this position, yet the agricultural world has not reaped half the benefit of Tull's favourite conception. It is one of the general laws of chemical combination that its efficacy is in the inverse ratio of the affinity of aggregation; for this latter power holds together the homogeneous particles, and prevents their separating and joining the parts of another body; and the greater the power is, the less efficacious must be the affinity of composition. All chemical action is combination or union, and decomposition or separation; and light and heat often appear as the new arrangements take place—heat is disengaged, and often absorbed, and a change of temperature happens. Bodies that have little or no affinity, and do not enter into combination, are made to do so by the addition of one or more substances; and this principle shows the necessity of applying a number of substances at one time, and of bringing them into contact with each other in a state of minute adherence. Many kinds of chemical action are effected by heat, electricity, and other agencies, over which any control is impossible, and which do not take place from mere mixture and comminution; yet, by that process, a ready accession of means will be afforded of producing combinations which, in another state of existence of the substances, would not have happened. All chemical forces are subordinate to the cause of life, and to heat and electricity, and to mechanical friction and motion. The latter power is able to change their direction, increase or diminish their tendency, and also completely to stop and reverse their action. But causes must exist to produce chemical affinity, or the cycle of life would stand still, and, from our ignorance of these causes and of the application, it is probable that, in many cases, their action is arrested and stopped, and often rendered useless or not produced at all—or, at least, but accidentally—arising from proceedings not being yet based on definite or measured causes.

The effects of manures of every kind depend upon the quality of the land to which they are applied, and also on the state of preparation of the soil at the time when the substances come into contact with each other. Finely-pulverized bodies cannot mix with those of a grosser form. Masses, lumps, and clods of homogeneous or heterogeneous substances will lie together, and remain in the original state

of cohesion ar aggregation; but no affinity of composition takes place at "sensible" distances, and consequently no results follow from the combined influence of the bodies in union. The contact of a pulverized substance with a mass or any gross formation, cannot produce the effects of combination. The finer particles of the former touch only the external surface of the latter, the interior parts remaining unaffected and unavailable for the purposes and effects of alteration. Hence the necessity of all substances that are brought into contact being reduced to the same state of minuteness, in order that combination may take place at *insensible* distances, and produce an active union from the reciprocal action of the molecules of the two bodies on each other. This affinity of composition is one chief agent in the operations of nature and of art; and the ease and rapidity with which bodies are decomposed, or enter into new combinations, are directly as the quantity of the surfaces that they present, or inversely as their masses. The efficacy of composition is inversely as the attraction of cohesion; the absolute force remains the same, but increases on account of the diminution of the opposing attraction. The investigations of science, the results of experience, and the conclusions of observations, unite in forming a powerful argument in favour of reducing to a state of the most minute subdivision possible all bodies that are intended to unite and incorporate with each other, in order to produce by their combined influences the substances,—liquid, solid, or aeriform,—which enter into the organs and structure, and promote the growth of plants. The materials must be applied in the greatest possible number of particles. On this point science is decisive, and nature shows the example of alluvial grounds and deposits, and in fact of all improved cultivation.

The portion of farm-yard dung that is first removed is pressed together in the heap by the carts treading over it, in order to prevent fermentation, till more manure be added from the yards, and till near the time of application, when the whole heap is turned over, and an active fermentation will take place, generating heat and the gaseous fluids. When this fermentation is going on, the application of the dung to the land must immediately take place, and in this process a very close and rapid combination of force must be adopted, that the dung may pass into the drill, and the seed be sown on it with the least possible delay, and derive the benefit of the heat and of the aeriform matters which are in the state of being disengaged: but in conducting the process attention and exertion will both be required. The land must be in a finely reduced state; the heaps turned over, in order

to produce fermentation, at the proper time, and the force engaged must be so arranged that the utmost possible dispatch may be obtained; and when the heap of dung is conveniently laid, it may be lifted, spread, and covered in the drills, and the seed sown in a period of not more than twenty minutes. A steam will rise from the heaps of dung in the drills behind the carts, which, being confined by the immediate covering of the dung by the ploughs, cannot fail in being of very great benefit to the germination of the seed, which is sown and pressed close down to the manure by a roll as soon as the fresh soil is thrown over it by the plough.

This is the most likely mode known to us of securing the benefits of fermentation during its progress, and also a greater quantity of manure; but it supposes a previous very careful attention to the management of the mass in the foldyards, that the organization of all the vegetable substances be saturated with urinary moisture, and regularly mixed with a due portion of the animal fæces, for the purpose of exciting fermentation both in the heap, and subsequently in the drill. We must not give the name of farmer to the person who allows the materials of farm-yard dung to be blown about by the wind, to lie in heaps at the door of the barn and stables, or burnt or dried to uselessness in the inside, while the outside is composed of dry straw, or who allows the moisture of a farm-yard to collect in a pond to float the geese and the ducks, or to escape by the gateway into the ruts of the road, or into a neighbouring ditch. The expense incurred in fitting the yard is not great, and more money is very often spent on other useless purposes. The continuation of the present management is reprehensible in the highest degree, and reflects great disgrace on the name of farming.

SECTION II. -EXCREMENTS, NATURE OF—NIGHT-SOIL, ANALYSIS OF—PIGEON'S-DUNG—GUANO, ANALYSIS OF—SHEEP'S-DUNG.

EXCREMENT, from the Latin word "excrementum," a thing separated, ἐκχώρημα, Greek, is any ordure or refuse that is separated or cast off from a body in shape of odour, sweat, spittle, or by any other way of parting from the body, and evacuated as useless, superfluous, and prejudicial. Excrements are also called "fæces," or dregs, the term being generally applied to all refuse and sedimentary substances, but more particularly to the excrementitious matters of the intestines, or the alvine excretions. Fæces vary from a fluid to nearly a firm and solid state in different animals, and in the same animals at different times. The colour also varies much,—the dung of pigs is generally

greyish, that of the horse and cow a dark green, that of the dog varies from white to black, and is more or less yellow in man. In some other animals it is white like chalk, and red from the flea and bug, and from other insects it is green. The quantity of bile is supposed to give the different colours, and the fetid smell has been attributed to an incipient fermentation during the progress through the intestines. But more improved knowledge from later discoveries does not allow this opinion, or that any real putrifaction can exist or commence in a living body.

"NIGHT-SOIL" is the excrements, the alvine secretions of human beings, the debris of food, and contains .—

Water,*	73·3	Salts,	1·2
Vegetable and animal remains	7·0	Slimy matter, being resin of bile, peculiar animal matter, and insoluble residue,	14·0
Bile,	0·9		
Albumen,	0·9		
Peculiar extractive matter	2·7		

The relative proportion of the salts 1·2 being :—

Carbonate of soda,	·035	Ammonio-phosphate of magnesia	·2
Chloride of sodium	·4	Ammonio-phosphate of lime,	·4
Sulphate of soda,	·2		

Night-soil is not lasting in its effects, as it leaves no residuum, or earthy matter for decomposition, quick, from the elastic principles it contains in a loose state of combination; and hence it requires to be mixed with heavier earthy materials, as earth, peat, loam, and decayed bark, in five times its bulk; and a little quicklime is usually added to kill the effluvium. It is also mixed with water so thinly as to be thrown on the land with scoops, but may be better applied in composts as a top-dressing. It has been reckoned five times the value of horses' dung, and when properly prepared and employed, the most delicate garden vegetables and field esculents can be produced without receiving any perceptible tinge of smell or taste. A very bad taste that has been noticed is supposed to arise from an excess of growth, forced by its fertilizing powers, and not from any intrinsic noxious quality communicated by the excrement to the plant. In China it is dried and made into cakes with one-third of their weight of marl, and then forms an article of sale in the commerce of that industrious people.

Night-soil has been desiccated and exported in casks, and similar preparations are made with animal matters, and called "Desiccated Composts;" they are applied by the drill to turnips, or sown by the hand on the seed of the crops, and harrowed in with it. "Animalized carbon and carbonized humus" and "urate" are manures of similar

composition, and are applied to the same purposes. These artificial manures are applied at the rate of five or six cwt. to an acre, and are manufactured by companies in London.

A very cheap and useful mode of collecting night-soil might be adopted by providing each privy with a close cask set on a pavement floor, or on a platform provided with wheels, and the floor extending backwards the size of the cask behind the privy, and that space may be uncovered or provided with a lid to open as occasion may require. When the cask is full, it may be pulled backwards and lifted into a cart by a movable lever of strong lifting power, and may be conveyed away and emptied into the reservoir containing such substances, to be mixed and incorporated with them. The cask will contain both the solid and urinary excretions, the complete absorption of which by earthy substances cannot fail to form a compost of great richness and value. Ashes in a fine state of reduction, earths, lime, sawpit-dust, and similar substances, may assist to diminish the smell, absorb the liquids, and form a solid mass that may be easier removed. This method is in the power of every farmer, and by it night-soil is equally available as any other substance on the farm.

"PIGEON AND POULTRY DUNG" is of a very powerful nature, but hot and stimulating, and abounds with the volatile alkaline principle. It affords carbonate of ammonia, and leaves as a residuum carbonate of lime and saline matter, chiefly common salt. It should be applied fresh, as fermentation diminishes the quantity of soluble matter. The dung of poultry contains silica, and phosphate and carbonate of lime, and, along with the dung of pigeons, has been dried, broken down, and powdered, and mixed with earthy substances, and applied during moist weather, and covered by the harrowing of the seed, at the rate of from forty to fifty bushels on an acre. If applied fresh, the quantity must be very small; and the readiest way may be to spread it evenly on the top of a dung-heap just before being turned over, which would mix the substances, and extend the benefits equally. The excrements of animals—as birds, dogs, swine, poultry, and pigeons—that eat food of nature and preparations similar to that of man, is of much better quality as a manure than that of those animals—as cows and horses—that are fed with grass and uncooked food; but the difference may be partly owing to the constitutional structure of the animal, and the nature of the digestive organs. The dung of the ruminating animals is more mixed with saliva, and may be better on that account; it is less disposed to putrify than some others, and may add more of the earthy matters to the soil. A man and a dog—fed on

the same substances, animal and vegetable—will afford, in the different nature of the excrements, a most notable example of the various materials into which the food has been transformed in passing through the different organs of digestion.

The dung of birds requires to be spread about and mixed with earth, sand, or ashes, to mollify the fiery heat and prevent the clinging together; it also requires to be spread thinly, being naturally very hot and strong. The poultry-house being strewed with sand or earth mixes the dung as it is dropped, and it may be further mixed in the dung-heaps. Rabbits' and deer's dung has been reckoned superior to that of pigeons, and all of them should be used fresh, or be mixed with earths in such quantities as will prevent the fiery and corrosive fermentation. The dung of pigs is of a cold saponaceous nature, and in some countries is used for soap. It is now mixed in the yard with that of horses and cattle.

The excrement of birds—which is found in large quantities in the South Sea Islands—is now imported into Britain, and has been found to be a manure of considerable value. It is called "guano," and is used extensively as a manure in South America. We give the analysis of it by Dr. Ure:—

	grs.		grs.
Urate of ammonia, . .	9·0	Sulphate of potash, . .	5·5
Oxalate of ammonia, . .	10·6	Sulphate of soda, . .	3·3
Oxalate of lime, . . .	7·0	Sal ammonia, . . .	4·2
Phosphate of ammonia, .	6·0	Phosphate of lime, . .	11·3
Phosphate of ammonia and magnesia, ...	2·6	Clay and sand, . . .	4·7
		Clay and organic matters, .	32·3

The last item, 32·3, is loosely given, or this analysis might be taken as a fair sample of fertilizing guano.

Another sample analyzed by Dr. Ure was partly decomposed, and had begun to emit an ammoniacal odour, to present an alkaline reaction, or a perceptible evolution of the volatile alkali. The total constituents were found to be—

I. Of matters soluble in water, 47 grains.

	grs.		grs.
Sulphate of potash and soda,	6·0	Sulphate of ammonia, . .	2·00
Muriate of ammonia, . .	3·0	Oxalate of ammonia, . .	3·23
Phosphate of ammonia, .	14·32	Water, ...	8·50
Sesqui-carbonate of ammonia,	1·00	Soluble organic matter and urea,	8·95

II. Insoluble matters, 53 grains.

	grs.		grs.
Silica, or flint, . . .	1·25	Sub-phosphate of lime, .	22·00
Undefined organic remains,	9·52	Phosphate of magnesia and ammonia, ...	4·50
Urate of ammonia, . .	14·73		
Oxalate of lime, . . .	1·00		

Dr. Robertson, in his History of America, published in 1777, mentions that the natives of Peru enriched the soil with the dung of sea-fowls, of which they found an inexhaustible store in all the islands situated along their coast. The Spaniards continued the custom from the ancient Peruvians, and used it as the chief promoter of every cultivated vegetable. The first specimen was brought to Europe in 1804, by Baron Humboldt, when it was examined chemically by Fourcroy and Vauquelin. It showed one-fourth of its weight of uric acid, partly saturated with ammonia, small quantities of sulphate and muriate of potash, phosphates of ammonia, magnesia, and lime, also some flinty and ferruginous sand. Nearly thirty years elapsed after this introductory notice of guano before the substance attracted much observation; it was mentioned by Sir Humphrey Davy, and recollected by Sir Joseph Banks, and trials on a small scale were made to test its efficacy as a manure. It was also ascertained, beyond all doubt, to be a vast accumulation of fæcal matter from sea birds, chiefly of the gull, gannet, pelican, and cormorant families, vast flocks of which, at certain seasons, darken the air as they move along in these latitudes, and repose invariably on the same spots, there passing the night; the quantity of excrement or guano, therefore, is unceasingly augmented; and as little rain falls in that part of the world, the surface is never washed or liquefied by heavy rains, the mass consequently becomes solid, and requires to be removed by the power of man.

In its native country, guano gets mixed with sand, salt water, and occasional rain. The irregularly accumulated masses slip down the declivities, where the birds never roost, and where the substance is exposed to the washings of the spray of the sea, and to the cohesions of sand from the top and sides of the hollow places in which it is lodged. Hence, as is the case with similar substances, no two samples are found to agree in their constituents, and as the colour is of a brown tint, guano is very easily adulterated by mixtures of sandy loams. This is said to be practised extensively by dishonest traders.

The Peruvians apply guano by putting a small quantity in the bottom of each hole, over which the crop is planted by the dibble. When the plant rises above the ground, more guano is diffused as near to the roots as possible, and watering is never omitted, thus showing that moisture is necessary for its action.

Little more than ten years has elapsed since guano was generally known as a manure over Britain, and during that time the substance has been established as a very valuable auxiliary manure, equal to

bones in many cases, and even reckoned superior by some persons to that powerful fertilizer, on light soils. Like bones, guano requires a soil of fine texture and warm composition, and also a benign climate, in which dryness and sunshine prevail more than cloudiness and humidity. These are the provisions of all auxiliary manures, and yet they require a certain degree of moisture for their action. The price of guano is now about £10 per ton, and the allowance of five cwt. to an acre reduces the cost to an amount that cannot exceed the means of application. This quantity supposes the sole use of guano as a manure for turnips, and the crop to be eaten on the ground by sheep. It is now considered better to lay about twelve one-horse cart-loads of farm-yard dung into drills, to cover it by reversing the drills, and to sow, by means of Hornsby's drop drill machine, two cwt of guano over the dung, the guano being mixed with fine dry soil or finely-sifted ashes, and the turnip seed being deposited along with the mixture. There is much to recommend this treatment, the quick and spirited action of the guano pushes forward the turnip plant very early into the rough leaf, placing it beyond the reach of enemies, and when its more evanescent qualities begin to fail, the roots of the plants reach to the farm-yard dung, which supplies the more durable nourishment throughout the season, and also leaves by decomposition an earthy residuum as food for the support of future crops. In both these ways guano proves advantageous, besides being commendable for its lightness of carriage. The average importation of the last five years into Britain exceeds two hundred thousand tons, the last two years being rather stationary than advancing, chiefly from the high price demanded by the Peruvian government, with whom it is a monopoly. Other sources for a supply of guano have been discovered, but it is of no use seeking for a useful guano in any locality where much rain falls; one week of wet weather in a year would carry away all the ammonia, and reduce it from being worth £9 5s. a ton to less than £4. If it were not for the rain, our own Land's End, Ailsa Craig, and other isolated spots, would furnish plenty of guano without going round Cape Horn for it.

Good guano is to the farmer what insurance is to the merchant—it guarantees to him the profits of his labours. After the husbandman has ploughed, harrowed, and sown, the application of this potent manure insures to him a return for his labours. Unfortunately, the temptation to adulterate it is so great, and the facilities for doing so are so numerous, that unless the farmer purchases of the importer direct, or some highly respectable dealer, he cannot feel certain that

he has obtained the genuine article. As it is of the highest importance to him that he should obtain it free from adulteration, the following remark will help to show to him if the guano is adulterated Peruvian or not.

A good ordinary test is to burn 200 grains of guano in an open fire, in a common sixpenny iron ladle, stirring it frequently; after keeping it at a strong red heat for ten minutes, and allowing it to become cold, if the ashes weigh more than seventy-two grains it is not genuine Peruvian guano. This test never fails, but the evidence derivable from chemical analysis is still safer, and much to be recommended.

Adulterations of Peruvian guano with sand or fine clay may be made so as to deceive the eye; but an adulterated sample, when compared with the genuine, by weighing a similar bulk, and by burning and then weighing the ashes, cannot escape detection.

The quantity of guano imported last year from Peru was 95,083 tons, which at £9 5s. per ton amounted to £889,000; and the quantity [illegible] other localities was 21,842 tons, which at £4 is equal to [illegible] together, £976,000 paid by the agriculturists for this manure alone—unquestionably a very large sum of money, and therefore it fully justifies the examination of this subject in all its bearings.

Liebig asserts, in his Chemical Letters, that "he believes the importation of one cwt. of guano is equivalent to the importation of eight cwt. of wheat; the one cwt. of guano assumes, in a time which can be accurately estimated, the form of a quantity of food corresponding to eight cwt. of wheat." In other words, 9s. worth of Peruvian guano, in a twelvemonth, is converted into thirteen bushels of wheat—say, worth £3 5s.

SECTION III.—Of Liquid Manures.—Human Urine—Urine of Horses—Urine of Cows—Trials of Application—Results—Blood—Ox Blood—Human Blood—Sea-Water—Stagnant Water.

Urine (derived from the Latin, urina), is the saline liquid secreted in the kidneys of animals, and dropping from them "guttatim" through the ureters into the urinary bladders. It is an excrementitious fluid, by which the body is liberated from superfluous water, salts, and animal earths, and defended from corruption.

Human urine contains, by analysis, the following constituents, in 1000 parts:—

Water,	933·00	Free lactic acid, lactate of ammonia, animal matter soluble in alcohol, and urea,	17·14
Urea,	30·10		
Sulphate of potass,	3·71		
Sulphate of soda,	3·16		
Phosphate of soda,	2·94	Earthy phosphates,	1·00
Common salt,	4·45	Uric acid,	1·00
Phosphate of ammonia,	1·65	Mucus of the bladder,	0·32
Sal ammoniac,	1·50	Silica,	0·03

The urine of horses contains of saline and mineral substances in 100 parts :—

Carbonate of lime,	21·75	Sulphate of soda,	11·03
Carbonate of magnesia,	11·26	Silica,	9·52
Carbonate of potass,	32·12	Oxide of iron,	0·79
Common salt,	6·27		

The urine of oxen differs from that of the horse. It contains of saline and mineral ingredients, in 100 parts :—

Carbonate of lime,	1·07	Sulphate of potass,	13·30
Carbonate of magnesia,	6·93	Silica,	0·35
Carbonate of potass,	77·28	Oxide of iron, and loss,	0·77
Salt, *i.e.* chloride of sodium.	0·30		

The urine of the cow, when quite fresh, contains at least twenty-one ingredients, some of which—phosphate of lime, chloride of potassium and sal ammoniac, sulphate of potass, carbonate of potass and ammonia, urea—are held in solution, with 92·624 of water; but at a month's end important changes have taken place. much more ammonia is evolved at the expense of three-fourths of the urea. Saline substances are formed by combination, and the water is increased to 95·442.

The specific gravity of animal urine is generally from 1·015 to 1·020, and of human urine 1·005 to 1·033.

In Holland and Belgium urine is much used as a manure, and is preserved in tanks made for the purpose. It is mixed with the excrements, rape-cake dissolved, and the contents of the adjoining privies; and the only preparation required is the solution of the cake, and the putrefaction of the contents. It is applied to the land at the rate of 2500 gallons per acre, by means of scoops, from a water-cart. In China, human urine forms one-fourth of all manures, and is always used in a putrefied state; in Tuscany and Switzerland, urine and liquid compositions are spread over the grass lands, and even fetid water, impregnated with a solution of animal and vegetable substances, is found to act more quickly than solid materials. The Flemings and

Chinese putrefy the liquid, and then dilute it. Chemistry has recommended it to be used fresh, as putrefaction dissipates the soluble matter, and as, in an unmixed state, it would contain too much animal matter to form a fluid in a fit state for absorption by the roots of plants. But it is admitted that putrid urine abounds in ammoniacal salts, and though less active than fresh urine, is a very powerful manure.

In our country, the following results have been obtained from comparative trials. The urine was gathered in a tank, diluted with four times its bulk of water, and applied from a water-cart:—On turnips, the effects were inferior to those of farm-yard dung by one-half. On potatoes, the roots were watery and unfit for use; dung should be applied at the same time. On barley, the crop was heavy, but soft and spongy, and fell down. On wheat, the effects were good on dry soils; on wet clays, it should be applied when the land is dry. On oats, the crop was increased by one-third; and on grass lands the application was successful; but it should be used in rather moist weather.

Much of the land on the continent, where the application of liquid manures is so general and successful, is under a regular alternate cropping and frequently manured; and consequently requires manures of quick effect rather than of durability and gradual operation. Much of this may depend on the soil, and probably more on the climate. In our system of farming, where much litter is used, it would be a wasteful practice to deprive the farm-yard dung of the saturation by urine, produced by pumping it from the tank made to receive it over the dung in the yards; in case of a very great abundance of the liquor and want of straw to absorb it, collect it in a pit, and absorb it with earths, as the most economical and profitable mode of application.

Blood is the red fluid that circulates in the bodies of animals, and has a saltish taste, a urinous smell, and a gelatinous consistence. On being exposed it is soon deprived of its volatile parts, which fly off in the nature of sal ammoniac. It soon congeals, and forms a trembling mass, of which the coagulated part is called the "crassamentum," and is highly inflammable on being deprived of its watery particles. The other portion is the "serum," or thin part, and contains albumen, water, and a ropy mucus.

Ox blood contains in 1000 parts:—

Water, ...	905·	Muriate of soda and potass,	2·565
Albumen, . . .	79·99	Soda and animal matter, soluble only in water, .	1·69
Lactate of soda and extractive matter, . . .	6·175	Loss, ...	4·75

Serum of human blood contains:—

Water,	905·	Chloride of potassium and sodium	6.
Albumen,	80·	Soda, phosphate of soda, and a little animal matter,	4·1
Lactate of soda and animal matter,	4.	Loss,	0·9

The above results differ according to the state of the animated body, and other circumstances. The buffy coat of the blood is fibrin, and closely resembles albumen in chemical properties. The specific gravity of blood is generally about 1.0527.

Blood is a manure of good quality, but its effects are not lasting. It has been much used for fruit trees, but the very limited quantity that can be obtained will deprive it of much attention, and a bed of fine earth, or of ashes, or of saw-pit dust, or any similar substances to absorb it, would appear to be the most economical preparation. It is mostly mixed with the offals of slaughter-houses, and with the ashes and animal dung in the pits of butchers' shops, where a substance of great value is found for mixing with farm-yard dung.

Sea-water has been used in saturating dung-heaps and fold-yards near the coast, where it can be got within the reach of moderate expense. Sea-water contains, in 1000 parts of water .—

Water	964·745	Sulphate of Magnesia (Epsom salts)	2·296
Chloride of sodium	27·059	Sulphate of Lime	1·406
Chloride of Potassium	·766	Traces of Iodine and ammoniacal salt	·033
Chloride of Magnesium	3·666		
Bromide of Magnesium	·029		

Specific gravity at 60° varies from 1·0269 to 1·0285; it is heavier than water owing to the saline ingredients; the latter substances are not much altered by difference of latitude, and the gravity is greater near the tropics and less at the equator, probably owing to the great quantity of rain that falls there. The saline taste is chiefly owing to the common salt it contains; the nauseous taste is attributed to the magnesia, and to the animal and vegetable matters found near the shores, and at the surface of the ocean.

The application of liquids was believed not to confer much benefit on land, since it appeared to impart to the residual matter for future decomposition. But since the discovery of the means of fixing ammonia, its compounds, and of many salts, by loamy soils, a very different view of the value of liquid manures must be entertained.

The ammoniacal liquor from the gas works, being the liquid in which street gas has been cleansed, is thought to contain, in solution, the acetate and carbonate of ammonia, and consequently to be favourable to vegetation. Four hundred gallons on an acre have produced

a very striking superiority on a crop of barley, but further confirmation as to the comparative merits of expense and durability is required.

Stagnant water which has become fetid by the solution of animal and vegetable matters, the steeps of hemp and flax, and dunghill water, have been recommended to be applied on grass lands, from the effects that were produced in several instances of application. The fertilizing effects of impregnated fluids, even of rain or river-water itself, need not be questioned; but the most economical use of such liquids is to apply them to the saturation of dung-heaps in the fields, or to the earthy composts in the pits appointed for the reception and mixing of such fluids and solids. By this mode the land will receive the liquids mixed with earths, and have the double benefit of the quick and lasting manures in a state of co-operation, promoted by the action of the soil, and the decomposition of the solid residuum.

SECTION IV.—On Dead Bodies and Exuviæ.—Animal Bodies, Nature of Them—Fish—Blubber—Oils—Greaves—Fellmongers' Poake—Furriers' Clippings—Hair—Feathers—Wool—Tendons—Corals and Corallines—Sponges—Larvæ of Silk Worms.

Animal bodies are putrescent in proportion to the number of constituent parts they may contain, and decompose much more readily than vegetables, from the nature, number, and looseness of the texture of the component parts, and the proportions of the elements of animal matter, and by the united agency of the component parts when the vital principle ceases to act. The liquid and soft parts of animals are quickly dissolved, but the hard and solid parts are long in being changed.

In all animal bodies there are contained gelatin, albumen, fibrin, mucus, fatty or oily matter, urea and uric acid, with other acid, saline, and earthy matters; and, as the latter or the former abound, decomposition will be slower or more rapid. All animal materials afford by decomposition much elastic volatile matter, and leave an earthy residuum composed of the fixed parts of the animal substances, with charcoal, oil, and ammonia, and require to be mixed with earthy substances in order to impart the juices to the compost, and thus increase the quantity and the quality of the manure. Dead bodies may be covered with ten times, or more, of their bulk of earthy substances to imbibe the oily and mucilaginous matters, and should be more than once turned over in order thoroughly to incorporate the mass. A

compost thus prepared, with a previous addition of lime to kill the effluvia, by imbibing the elements, carbon, hydrogen, and nitrogen, as such an energetic body must have a chemical affinity for the elements, will be in a fine state to be applied as a top-dressing on any grass lands or clovers, or drilled or harrowed in with the seeds of crops. Slaked or cool lime may be mixed with the heap not long before it is used—it will not corrode the animal remains, from having lost its causticity, and, by combining with the other ingredients, will gently quicken their action, and add a soapy and very valuable quality to the compost.

Of all manures, the animal substances, when well prepared, are the most powerful promoters of vegetation. In that state, almost the whole body becomes volatile, and so far attenuated, subtilized, and refined, as to be rendered capable of entering the vessels of the minutest plants. So soon as the parts are sufficiently divided to be mixed with the earthy materials, the process of preparation must go on quickly, and as soon as incorporation has been effected, the application must not be long delayed, in order to prevent the great loss of bulk that will ensue from the rapid decay of the many complex elementary substances which compose the organization of the bodies.

Fish in a fresh state, or mixed up with earths and lime in composts, are often used as a manure in places adjoining the sea coast. Sprats are sown by hand from baskets on winter ploughing, and herring scales and water in which fish have been washed, might be useful, from being oily and bloody, and may be applied in a liquid state, or mixed with earth, dung, and turf. Salt fish and putrid flesh may be mixed with mould, and moistened with the washings of casks and brines, and mixed and well incorporated with other substances.

Scales of fish are composed of alternate layers of membranous laminæ and phosphate of lime, to which they owe their brilliancy. The skin of fishes is chiefly gelatine, and easily soluble in water; oil and fat abound in the body and in the viscera, and are easily changed by the action of air and water upon them. Hence the transient nature of fish as a manure.

Blubber is the fat or *adeps* of the body of the whale, and lies between the skin and the muscular flesh, mostly fibrous, and varying in thickness from two inches to three feet. One animal will afford 50 to 80 cwt.: in a fresh state it destroys vegetation; and is usually mixed with earths as a compost, after the oil has been extracted by boiling. The earth may be applied in ten loads to one

of blubber in layers, and must be well mixed by turning over, and cool lime may be applied before application, which may be done in top-dressings on arable or grass land at the rate of thirty to forty tons on an acre.

The fat oils are composed of carbon, hydrogen, and (with few exceptions) oxygen; they require to be mixed with a large portion of earth, and to be diluted with water. Whale oil mixed with earth in the proportion of one to three, has produced a good crop of turnips, and the cost was less than that of many other manures.

Greaves is a very powerful and durable manure, and is found generally in square compressed cakes, and not unfrequently in a soft state. It requires to be mixed with four times its bulk of earth, and afterwards well pulverized with an addition of mild lime, and then applied as a top-dressing, or harrowed into the land with the seeds of crops.

Fellmongers' poake, or cuttings, is used in the neighbourhood of large towns, and is composed of sheep's feet, scrapings of the pelts, and lime, and hair. Being of a very hot nature it should be well mixed with earthy substances, and often heated and turned; it is very suitable for top-dressing on clays, and on sour meadows, at the rate of ten tons to an acre.

Furriers' clippings are sown by hand on lands being ploughed for grain at the rate of three or four quarters to an acre. On dry gravels they are reckoned very useful in holding moisture; on clays they have shown little effect.

Hair is the dry, round, elastic fibres or filaments that arise from the skin, and are fed by the medullary juices. It is applied at the rate of thirty bushels to an acre by being covered in the land by one ploughing, or mixed with earths in composts.

Feathers consist mostly of inspissated albumen with a very minute portion of gelatine, so very small that a quill, freed from adhering oil, may be boiled many days in water without any apparent alteration, and the liquor does not acquire any new properties.

Feathers have been used at the rate of twenty to thirty bushels an acre, ploughed into the ground, or may be mixed and rotted in earths and similar substances. The effects are good and lasting.

Wool is in the form of woollen rags, and is sometimes used as a manure. These are useful on dry chalks and gravels in attracting and retaining moisture. They have been much used for manuring hops, but in dry seasons they attracted vermin, created dry mould, and did harm. They are best ploughed in for crop with one furrow, so as not

to be pulled above ground by the harrows, or they may be used as top-dressing on young grasses. A very excellent preparation may be effected by steeping them, when chopped into small pieces, in privies or urine-pits, and then they may be applied to any crops.

Tendons are strong brilliant substances, of a pearl colour, the termination of the muscles, and connect the parts of the body, and attach them to the bones; and ligaments are strong fibrous elastic bands which tie the bones together at the joints. They resemble the *cutis* in composition, obstinately resist the action of water, and after much boiling they retain their strength and form.

Corals and corallines and sponges are to be considered as animal substances, and afford matters analogous to coagulated albumen. *Sponge*, according to the analysis of Horneman, consists of a substance similar to osmazone, animal mucus, fat, oil, a substance soluble in water, a substance soluble only in potass, and traces of chloride of sodium, iodine, sulphur, phosphate of lime, silica, alumina, and magnesia. They will require reduction of texture, and considerable decomposition for the developement of their action as a manure.

The larvæ left after the cocoons of the chrysalis are reeled in the silk manufactories in France, contain more ammonia than any other animal substance, and are invaluable as a manure.

SECTION V.—On Bones.—Nature of them—Boiled, Raw—Application—Great Value—Horns—Shells—Crusts of Lobsters.

Bones are the most solid parts of the bodies of animals, and may be regarded as the walls of the building, containing and supporting the other parts. They are composed of hard fibres tied together by smaller transverse fibres and a vascular substance, and do not differ materially in structure from the rest of the body, except that in the interstices phosphate of lime is deposited, which gives strength, firmness, and rigidity to the whole mass. The earthy part is half the weight of the bones. The constituent parts are—

1. Gelatine, soluble by boiling water, and giving a fine clear jelly.
2. Oil, which rises to the top of the water when boiling, and when cold concretes into a suet.
3. Sulphate and carbonate of lime in considerable quantity.
4. A membranous or cartilaginous substance, retaining the form of the bone after every other thing has been extracted by water or by an acid; it much resembles inspissated albumen, by which it differs from gelatine.
5. Phosphate of lime.

The proportion of carbonate of lime in bones varies considerably even in the bones of the same animals, but is generally present in

domesticated animals in about one-eighth to one-fourth the quantity of phosphate of lime.

Ox bones contain, according to Berzelius :—

Cartilage, completely soluble in water, and vessels .	33·30	Phosphate of magnesia, .	2·05
Phosphate of lime (neutral),	55·45	Fluoride of calcium, .	2·90
Carbonate of lime, . .	3·85	Soda, with a little common salt, ...	2·45

Human bones contain :—

Cartilage and vessels, .	33·30	Phosphate of lime, . .	51·04
Soda and common salt,	1·20	Fluoride of calcium . .	2·00
Carbonate of lime, . .	11·30	Phosphate of magnesia, .	1·16

Bones are liable to *caries* when the phosphate diminishes. A carious bone gave :—

Animal matter, ...	40·5
Carbonate of lime, ...	21·5
Phosphate of lime, ...	38·0

The qualities of bones varies in different parts of the same body and in the relative proportion of fat, gelatine, and earth. The bones of young animals contain less earthy salt, and the large round bones of the thigh contain much more oil than the rib or blade bones ; on exposure the latter soon become dry and clean, but the former remain for a long time foul and greasy. The bones of boiled meat, though deprived of some of the extractive matter, are richer than when roasted ; and the hardest and driest bones, though kept for years, retain their gelatinous parts unchanged. This property may account for the fact that bones, after lying on land for years exposed, or even covered, have been again prepared, and have produced equal effects with new. The bones of fat animals are the best.

Bones are now mostly boiled before being crushed, and as much as three or four pounds of fat are extracted from a bushel of ordinary bones. They are then crushed in a grinding-mill, provided with cylinders which are furnished with teeth of different sizes, between which the bones are made to pass until they are reduced to the required degree of fineness. This latter mode yet wants confirmation, but the former is undoubted, and bones fresh from the grinding-mill have been used the same day, and have produced most excellent crops ; and it is probable that there are many counteracting influences in the state of the land and of the atmosphere of which we are wholly ignorant.

The quantity of bones allowed to an acre is about twenty bushels for turnips, and are sown in a continuous stream by a machine of two rows, or deposited at regular distances of eight to ten inches by a

drop drill machine, which is a very great and valuable improvement. Bones are chiefly applied to turnips, though the effects are equally good on other crops. If we look chemically at the constituent parts of bones, we shall conclude that the effects will be comparatively transient, the decomposable matters will be quickly dissipated, and there is no fibrous substance to add an earthy residuum to the soil, for the hardened substances will remain entire for a very long time, and may be taken up and re-ground, and applied with the same effects as before.

But notwithstanding this inference, bones are very justly considered as the most valuable fertilizing substance yet known; they are formed of phosphate of lime,—an essential element in all fertile land, and they contain fifty-five per cent. of phosphate of lime and magnesia, so that eight lbs. of bones contains as much phosphate of lime as 1000 lbs. of hay or wheat straw, and with as much phosphoric acid as eleven lbs. of the grains of wheat. The carriage, moreover, is light! the cost per acre comparatively small; the effects are nearly always certain, and bones approach the nearest to that condensed principle or fertilizing essence, limited in weight and in volume, which is so very desirable in shape of manure, and capable of being transported from one place to another at a moderate expense. Bones are now reduced by pouring over a given quantity, finely powdered, half their weight of sulphuric acid, diluted with three or four parts of water, diluting this again with a hundred parts water, and applied at the rate of three cwt. per acre, at the cost of £7 per ton. The only use of the acid seems to be its power in disuniting the texture of the bone and making it more speedily decomposable.

A fineness and warmness of composition is an essential desideratum in a soil for the use of bones, and on such lands, and with due preparation, success is almost always certain. If such manures be not durable they are yet highly useful in raising the elements of the more durable substances on any farm, when they do not already exist. The use of bones has already converted many a barren heath into a fruitful field, which sufficiently shows the value of the manure.

Horns contain very little earthy matter, and only 0·023 of phosphate of lime, and consist chiefly of condensed albumen, and a membranous substance very like to albumen in a coagulated state, and probably also a little of gelatine; and they seem to owe their solidity to the extreme condensation of these constituents. They soften by heat, are thin and transparent, elastic and flexible, but too tough to be pounded.

Hoofs are similar in composition to horns, and agree with talons and bills of birds, and hoofs and claws of other animals, in uniting a fibrous with a membranous or lamellated texture; water softens but does not dissolve them, and they are sometimes analogous to cartilage, and may be converted into a jelly. When burned in the quantity of five hundred grains, horns left only 1·5 grains of residuum, not one-half of which was phosphate of lime; like hoofs they are usually ground with bones, and applied with them. Horn chips and turners' shavings have been found very useful at the rate of sixty stone to an acre, ploughed in with wheat or barley; in a very dry season the effect failed, so they had better be mixed and applied with bones. Fish bones contain more cartilage than those of quadrupeds.

The shells of salt and fresh water animals are carbonate of lime united to a soft animal matter, and differ from bones, in which phosphate of lime is most abundant. They are the horny covering of shell-fish, and differ much in composition and in the quantity of animal matter, which resembles gelatine. Shells have a compact texture, an enamelled surface, often finely variegated, and have layers of coagulated albumen.

Crab and lobster crusts contain a cartilaginous substance very like to coagulated albumen, and also carbonate and phosphate of lime. This latter ingredient distinguishes them from other shells, and the excess of the carbonate above the phosphate from bones. The shells of snails are similarly composed, and oyster shells afford lime almost pure. Egg shells contain two to four per cent. of animal matter, and one per cent. of phosphate of lime and of magnesia, the other parts being carbonate of lime with some magnesia; and burnt shells contain traces of iron and of sulphur.

SECTION VI.—Vegetable Manures—Vegetables, Permanent and Deciduous—Wood or Lignin—Leaves—Contents of Ashes of Different Woods—Vegetable Moulds—Fern—Ashes of Vegetables—Fuci or Sea-Weeds—Kelp—Rape-cake—Malt Coombs—Tanners' Bark—Sugar Bakers' Scum—Sawpit Dust—Green Plants Ploughed into the Ground.

The word Vegetable is derived from the Latin, *vegeto*, to grow, being applied to the plants that grow on the earth, and derive sustenance from it by means of roots fixed in the soil or in some other body, and sometimes by the agency of pores over the whole surface of the vegetable itself, as in the case of submarine plants. This includes the aliments which the leaves of vegetables imbibe from the atmos-

phere, and convey to the plant to contribute to its growth by the enlargement of its parts. A plant is an organised body that has no sensitive or locomotive powers, or it is anything that grows without spontaneous motion or sensation. In the wonderful and incomprehensible economy of nature, it is seen that the three kingdoms,—the animal, the vegetable, and the mineral,—mutually and reciprocally support each other. The earths are metallic oxides, saturated with oxygen, and the minerals are earths in an aggregated form, and are suspected to have one common origin; and these two great divisions are by peculiar changes resolved into each other. The animal world is fed by the vegetable. In fact, the vegetable world is one vast laboratory, or chemical workshop, in which the food of animals is in process of preparation. Without vegetation animals could not subsist, —indeed, without it neither the atmosphere nor the aërated water in which they breathe would preserve their vivifying influence. A constant decay and reproduction, by an unalterable law of nature, goes on in every substance on our globe; the minerals afford material for the earths, the earth affords aliment for the vegetables, and the vegetables afford aliment for the animals; and these being subject to decay, are again converted into other substances, and return to support the original structures. Animals and vegetables have, then, stated periods of existence, and having performed the universal purpose of organized nature in propagating their individual species, they die, and afford by the decomposition of their bodies new elements of life to the quarter whence they derived it. Not only by their dissolution, however, do animals produce this effect, but by the continual parting with something pertaining to the process of their own nourishment that is redundant and excrementitious, are they found to assist in restoring the principles of support to the earths and minerals, the original source of their existence.

Plants are naturally divided into two large classes, the permanent and the deciduous, or the annual and short-lived plants, and the permanent, or those which remain for a long period of time. Trees and bulky vegetables that exist for a permanency, afford a yearly contribution of support, by the decay of the leaves; but the stems and roots remain long in existence. The smaller plants, grassy and herbaceous, are, many of them, annual, and yield a regular cycle of life and decay; while others that are more permanent, whose roots remain and produce for a long period, afford by the yearly decay of the fruit-bearing stem, and by the ultimate decay of the roots, a regular contribution to the ultimate purposes of vegetation. Vegetables yield, as

the fruits of natural decay, the black earthy substance called "vegetable mould," in which plants grow with great rapidity, and which constitute the fertility of newly-discovered countries, where it has been accumulating for ages.

Wood, or lignin, or woody fibre, is the ultimate product of vegetation in the form of trees, and consists of a series of longitudinal fibres in layers, bound together by a cellular and vascular substance, and decomposes very slowly, owing to the hardness of the condensed materials.

Leaves are the green deciduous parts of plants, which fall annually and return to vegetable mould, and seem to possess an antiseptic quality, for they remain long unchanged, though mixed with substances that are known to promote putrefaction. They have not yet been made the subject of a series of investigations, except in the case of tobacco, tea, and a few others, and a few medicinal plants. When they fall they are changed from the green succulent state to a dry fibre and a portion of earth, and are best used in composts, or in littering cattle yards.

The proportions of the constituent parts of the wood and ashes of some of our trees have been stated as under:—

Wood of oak, 1000 parts green, gave 2 of ashes; and 100 parts of such ashes gave, according to De Saussure:—

Alkalies and salts with alkaline bases	59·25
Earthy phosphates of lime and magnesia	4·5
Carbonates of earths	32·
Silica	2·
Metallic oxides	2·25

Soil from wood of oak, 1000 parts of the soil dry, gave 41 parts of ashes, and 100 parts of ashes gave:—

Alkalies and salts with alkaline bases	32·5
Earthy phosphates	10·5
Carbonates of earths	10·

The following table gives De Saussure's analysis of the wood and leaves of oak, poplar, and hazel. 1000 parts of the oak wood gave 2 of ashes, and 100 of the ashes gave the result in the table. In the soil from wood of oak 1000 parts of dry soil gave 41 parts ashes, and 100 ashes gave the product. 1000 parts leaves of oak, green, May 10, gave 53 ashes, and September 27, dry, 55. Of water 549. 100 parts ashes gave the product named. Wood of poplar, September 12, 1000 parts of the wood, dry, gave 8 of ashes; and of water, 26, and 100 parts of ashes gave, as in the table. Leaves of poplar, September 12, gave 93 of ashes from 1000 parts; when green, 41; and of water, 565;

and 100 parts of ashes gave, as in the table. Peeled wood of hazel, 1000 parts, dry, gave 6 of ashes; and 100 parts of ashes gave, as in the table. Leaves of hazel, September 20, gave 70 parts of ashes from 1000; when green, 31; and of water, 557; and 100 parts of ashes gave as in the table :—

Analysis of One Hundred Parts	Wood of Oak.	Soil from Oak Wood	Leaves of Oak	Poplar Wood.	Leaves of Poplar.	Peeled Hazel	Leaves of Hazel
Alkalies and Salts, with alkaline bases	59·25	32·5	42·5	50·5	44·	28·	44·
Earthy Phosphates of lime and Magnesia . .	4·5	10·5	18·25	16·75	7·	12·	14·
Carbonate of Earth . .	32·0	10·	23.	27·	30·	26·	29·
Silica	2·	32·	14.5	3 3	11·5	22·	11·5
Metallic Oxides . . .	2·25	14·	1·65	1·5	1·5	2·	1·5

The foregoing analyses are derived from De Saussure's tables. A few others only of more recent date appear. One of oak-wood ashes, made at the Laboratory of Giessen by Denninger, is cited by way of comparison :—

Potash	5·65	Sulphuric acid . . .	0·78
Soda	3·77	Silica	0·52
Magnesia	3·01	Peroxide of iron . .	0·38
Lime	50·58	Common salt . . .	0·02
Phosphoric acid . .	2·32		
			67·03

Loss not accounted for—nearly 23 per cent.

Wood of the horse-chestnut, 1000 parts, dry, gave of ashes 35; and 100 parts of ashes gave, soluble salts, 9·5.

Leaves of the horse-chestnut, 1000 parts, dry, gave 80 of ashes; when green, 31; and of water, 636.

Vegetable mould contains more charcoal, but less oxygen, weight for weight, than the vegetables from which it proceeded; it yields also more ammonia, and therefore contains more azote, arising from the different circumstances under which it is formed. By distilling 300 grains from the oak, the following products were obtained; the same quantity of undecayed oak yielded a different proportion of the same constituents :—

	MOULD.	OAK.		MOULD.	OAK.
Carburetted hydrogen .	124	110	Empyreumatic oil .	10	13
Carbonic acid . .	34	29	Charcoal . .	51	41½
Water containing acetate of ammonia .	53	80	Ashes . . .	8	0½

Vegetable mould, though it be the result of the putrefactive process, is not itself susceptible of putrefaction, but rather retards it; and remains unaltered because there are no other principles present in sufficient proportion to act on the carbon accumulated in it. But this is owing to the exclusion of the air, for on the mould being exposed a change takes place, and it is entirely decomposed; the oxygen of the air combines with carbon, and forms carbonic acid; while this proceeds, the abstraction of carbon appears to allow part of the oxygen and hydrogen of the mould to combine and form water; for it loses more of its weight than can be accounted for by the quantity of carbon extracted. These changes continue in a certain relation to each other until it is entirely decomposed, leaving the earthy and metallic substances that were originally contained in the vegetable matters. We see from this process of decomposition, how necessary is the frequent stirring of the soil, in order, by the action of exposure, to form carbonic acid for growing plants.

Wood, shrubs, and vegetables, when rendered incandescent in close vessels, afford the well known substance called charcoal; and by being burned in the open air, they leave a pulverulent residue, differing in composition according to the constitution of the vegetables. This residue is called ashes, and is the remains of anything burnt; from these the fixed alkaline salts, called potash and pearl-ash are extracted by lixiviation and crystallization. Wood ashes vary in composition in different plants; they contain soluble salts, earthy phosphates and carbonates, silica and metallic oxides. Vegetable ashes contain silex, magnesia, lime, potash, soda, the sulphuric, carbonic, phosphoric and muriatic acids, and the oxides of iron and magnesia,—gold has been mentioned, but it is supposed rather to proceed from some of the tests that are used. A violent heat will reduce the ashes to a slag or scoria, dissipate the saline ingredients, and leave only the earthy and saline substances; and it requires attention in managing the fire in order to procure the greatest quantity of ashes from vegetable matters. The alkali in ashes may be washed out by water, when the soluble part will be found to consist chiefly of a calcareous earth, some clay, and a small portion of magnesia. But the products will vary much in different plants.

The different substances found in the ash of plants are generally the following:—potash, soda, lime, magnesia, silica, alumina, oxide of iron, oxide of magnesia, sulphur, phosphorus, and chlorine. The quantity of ash, yielded by different plants, varies greatly; thus, in 1000 lbs. of the following vegetables:—

Wheat . .	12lbs. of ash.	Oat straw . .	51lbs. of ash.
Barley . .	20 "	Rye straw . .	40 "
Oats . .	35 "	Indian corn .	44 "
Rye . .	10 "	Pea straw . .	30 "
Indian corn .	15 "	Meadow hay .	60 to 100
Beans . .	30 "	Clover hay . .	90 "
Peas . .	28 "	Ryegrass hay .	95 "
Wheat straw . .	51 "	Potatoes and turnips	3 to 7
Barley straw .	53 "	Carrots . .	9 "

The saline substances are supposed to act on inert soils and on moulds, and to render matters soluble and fit to nourish plants. The alkalies are manures educed from vegetables by fire: they attract carbonic acid and hasten decay, from containing a small quantity of common salt and Glauber salt. Ashes are liable to be lixiviated and carried away by moisture, and consequently must be protected by some covering. Soap-suds and chamber leys will add to their strength, and two to six loads are applied to an acre; when mixed with mud, one load is reckoned superior to ashes alone, and four times better than mud alone. The fixed vegetable alkali forms with sulphuric acid a vitriolated tartar, neutralizing the acid, and becomes very favourable to vegetation. They may be well mixed with earths and leaves, and applied on grass lands at the rate of ten to twelve loads an acre. Forty, sixty, or a hundred bushels to an acre have been laid on young wheats and clovers as top-dressings, and they may be harrowed in with the seeds of turnips and of barley in an unmixed state. Ashes suit well for turnips in promoting a quick and early growth, and are thought to be useful in preventing the ravages of the fly, and require a degree of moisture to promote their efficient action. The ashes of burnt straw and of stubble, left on the ground after the reaping of the crops, have been found very useful in killing weeds and in promoting vegetation; straw has been carried to the field and burnt for a manure at the rate of four to six loads to an acre; but such a quantity must very much diminish the bulk of farm-yard dung, and any diminution of that essential article cannot be recommended without finding a more effective substitute, and which has not yet been discovered either in the shape of ashes or any other substance. The dust of charcoal is of great use to all wet and sour lands, it is used in the same manner as soot and wood ashes. It is composed of the bits of charcoal broken off in handlings and of the turfs that are used as a cover to the pile of wood in smothering the fire. It will thus contain much carbonaceous matter.

Fern forms the order of filices in the cryptogamous class of plants

in our artificial system of botanical arrangement. The genera of ferns are numerous, but only one plant comes under the notice of agriculture, the common brake; it is very generally diffused over cultivated grounds and heaths, and is often found on soils of good quality. The roots spread horizontally and deeply into the ground, and are often of difficult extirpation; frequent mowing of the plants, and ploughing and dunging have been recommended, and, above all, the pouring of urine upon them; sheep folded closely upon ferny ground will banish the plants by reason of the dung and the urine.

Fern has a salt mucilaginous taste, and was formerly much used as a medicine; and the country people yet retain it in powder to destroy worms, and a bed of the green plants is reckoned a sovereign remedy against the rickets in children. The stems tied together make a very durable thatch, and afford a very violent heat in burning. They are used, where coal is scarce, to heat ovens and to burn limestone. The roots, boiled in wash, are much relished by swine; in Normandy they are mixed in bread; and in Siberia they are brewed in ale in the proportion of one-third of roots to two-thirds of malt. It is very astringent, and is used in preparing kid and chamois leather.

When this plant is cut in a green state and left to rot on the ground, it very much improves the land, and the ashes afford double the quantity of salt of any other vegetable. The ashes are often mixed with water, and formed into balls and heated in the fire, and then used as an alkaline ley for scouring linen. Fern ashes yield about one-ninth of their weight of salts, chiefly the sulphate and carbonate of potash; 1000 parts of the plants cut in August and thoroughly dried, afforded 36·46 of ashes, which yielded by lixiviation 4·5 of salt; 100 parts of the following vegetables, being thoroughly dried, were burned by an open fire, and the ashes weighed and then lixiviated till all their saline contents were extracted:—

100 Parts	Ashes.	Salt.	Salts from 100 parts of Ashes.	100 Parts	Ashes.	Salt.	Salts from 100 parts of Ashes.
Nettle	10·67	2·5	23·4	Aspen	1·22	0·07	6·1
Fern	5·	0·62	12·5	Fir	0·34	0·04	13·2
Do.	3·64	0·42	11·6	Heath	—	—	11·5
Buckwheat	—	—	33·3	Wormwood	9·74	7·3	74·6
Sallow	2·8	0·28	10·2	Fumitory	21·9	7·9	36·
Elm	2·3	0·39	16·6	Sonchus arvensis	10·5	1·96	18·6
Oak	1·3	0·15	11·1				
Beech	0·58	0·12	21·9				

Hence we see that succulent herbaceous plants yield a much greater proportion both of ashes and salt than the shrubby and ligneous structures; but they were all very well dried, and wood will lose only one-third or one-fifth in drying, whereas many succulent plants will lose as much as nine-tenths, which may account for the difference.

Ferns make a good litter for cattle, and are cut, dried, and stacked for that purpose; they remain long unchanged, and should be laid in the bottom of yards or similar moist places, where they may be completely saturated. The ashes are used as a top-dressing, mixed or unmixed, on young crops, and with good effects. The plants should be cut while green, or before they decay; for plants that contain much fixed alkali are liable, when withered, to lose it by every shower that falls. Where they abound they will be very useful during summer in littering the yards and stables, and a quantity may be stored for winter, and may be cut by the straw-cutting machines, which will very much facilitate the reduction of the rough, stringy, fibrous texture.

Sea-weeds, or "Fuci," are much used as a manure in places near the sea coast, where they can be obtained. The "fuci" constitute an extensive order of the cryptogamous plants, and all of them have a thin, gelatinous, and coriaceous substance; and the root, stem, and leaves, all of similar composition. The kinds most common are:—1. Fucus serratus; 2. Fucus vesiculosus; 3. Fucus nodosus; 4. Fucus palmatus; 5. Fucus siliquosus; 6. Fucus digitatus, and these are much mixed with other species, and with the "ulvas and conferva." Some of the plants are cooked and used as a food, and the "Fucus saccharinus" or "Dulse," is used in a raw state or dried.

Marine plants abound in soda, or the fixed mineral alkali, and have been found to contain one-eighth of a gelatinous substance, similar to mucilage, and four-fifths of its weight of water, but no ammonia. The ashes contain sea-salt, carbonate of soda, and carbonaceous matter; the gaseous matter is small, chiefly carbonic acid, gaseous oxide of carbon, and a little hydro-carbonate, and the water of boiled fucus has an empyreumatic and slightly sour taste, and the ashes, when applied as dung, have been known to improve the quality as well as the growth of esculents.

The fuci contain as many as twenty-one ingredients, the chief of which are soda and potass.

Sea-weed quickly loses both bulk and quality by exposure and fermentation, and therefore requires immediate application to the purpose

intended. The effects on land are very great, but transient, probably from the great quantity of water, or the elements of water which it contains. It melts and dissolves on exposure without any heat being evolved, and it is supposed that the carbonic acid formed by the incipient fermentation, when applied fresh, must be partly dissolved by the water set free in that process, and thus become capable of absorption by the roots of plants. Sea-weed, fermented, was found to lose one-half of its weight, and afforded less than one-twelfth of mucilaginous matter, so that fermentation must destroy that substance. The effects of this manure are supposed to depend chiefly on this carbonic acid, and the soluble mucilage it contains, which latter substance fucus loses by fermentation. It is applied fresh with great success on stubbles before the winter ploughing, and on leys before being ploughed for oats, and on wheat fallows before being seed-furrowed, and also as a top-dressing on grass lands. The quality of earthy composts is most prodigiously improved by a mixture with seaweed, laid on the top before the heap is turned over. Seaweed is also very profitably used in mixing farm-yard dung in the cattle-yards, laid in thin layers alternately with the straw, and manures of the most valuable quality have been produced by this method. It has been laid in drills in a fresh state as a manure for potatoes with much success, and no watery quality was imparted to the roots; but in other cases the practice is said to have been abandoned from that circumstance. Farm-yard dung is almost incredibly improved by a mixture of seaweed, moisture is imparted, the straw is decomposed, and the whole mass is converted into a juicy mucilaginous state, and never fails to vindicate the expectations of its effects. We close the present observations by observing once more, that sea-weed is to be applied without delay to whatever purpose it may be intended.

Kelp is a mixture of the fossil alkali or soda, and of sea salt, besides earth and stones. It is burned from sea-weed for the purpose of making glass and soap, and is now very much superseded by the formation of soda from sea-salt, a much purer substance, containing nearly thirty per cent. of alkali, while kelp contains only about six per cent., and is known as the carbonate of soda. It must be reduced to powder by machinery and by pounding, and being acrid and caustic, it may be mixed with earths and sands, at the rate of three or four cwt. to an acre, and should be used in a moist state. It is much of the nature of potash and lime, and may be used as a top-dressing, and may be lightly covered in on the surface of the land for turnips or any young crops; and on heavy lands the quantity may be increased. It usually

sells at about £3 10s. per ton; but the expense of burning, and the very small quantity obtained from a great bulk of sea-weed—one ton from thirty—may ever prevent any extensive use of it as a manure by that mode of preparation. The few trials that have been made have shown very fair results. Mixing it in the land, or in composts, is most essentially necessary.

RAPE-CAKE consists of the husk and refuse of the seed of the rape plant after the oil has been extracted. It is reduced to powder in a mill, and may be sown on clovers and young crops at the rate of ten or twelve cwt. to an acre, when it will decompose quickly by the attraction of moisture. It must be kept dry, and it suits damp soils better than those of a light and sandy nature. Rape-cake, and all oleaginous bodies, contain carbon and hydrogen, which renders them effective as manures. Linseed-cake is of a similar quality, but is too valuable to be used for the purpose of manure. The Flemings use very large quantities of rape-cake, and of poppy seed; and, by mixing these substances with urine, they obtain manures of great value and effect. The dust is reckoned to be destructive of most insects, and when mixed with elder and wormwood, it is thought to be an antidote against the wireworm.

Rape-cake has been drilled in the spaces between the rows of wheat in March and April, with the view of affording to the plants the benefit of the manure at that season of growth, and to divide the effects; for if all the quantity be sown in autumn, the plants would grow too strong, and get root-fallen. It requires moisture in the soil or in the weather; in hot and dry situations it remains long inactive, and the effects of it, from regularly made experiments, are yet very doubtful, though in certain places and circumstances it has acted well, at the rate of five cwt. to an acre. It has been observed to do best on clays and damp loams, and best on all lands in moist seasons, and may be mixed with dung or other substances, and along with pigeon's dung, and similar materials may be steeped in reservoirs of urine and seeds. The article seems too small in bulk to be used broad-cast on wheat fallows, though it has been tried on fine soils with fair success. The present price is from £4 10s. to £6 per ton.

MALT COOMBS consist of the radicles of seed protruded by vegetation, caused by steeping barley in water for malting, and which are rubbed off during the process of kiln-drying and cleaning. They must contain saccharine matter, and are used for feeding cows and pigs, and for being spread on the floors of pigeon and poultry-houses, and also as a manure. The dust of low-dried malt is not so stimulant

as that of high-dried; but more lasting from that circumstance and the quality of the barley. It is used dry and unfermented as a top-dressing on wheats, at the rate of forty bushels on an acre, and may be drilled with the seed of barley and turnips at the same rate, and is often scattered on the last harrowing of barley land, and then rolled. It sells at 5s. to 6s. per quarter, and as much as ten quarters an acre have been used for wheat, eight for barley, and four on clovers; the effects are quick, and it may be mixed with lime and salt, earths, and stable dung, and kept moist and covered from rain, and twice or thrice turned over and mixed. Such light manures as require no preparation by decomposition, and are not too gross or caustic to be applied by themselves, may be most economically used in an unmixed state, and without that expense that must attend every step in the preparation.

Tanner's Bark is the woody fibre or bark of oak trees, that has been used for the purpose of imparting the tanning principle to leather in the pits, and is thrown out as useless after the soluble parts have been extracted. It is long in fermenting and resists putrefaction, and though it be both very absorbent and retentive of moisture, it is impenetrable to the roots of plants. It is much used by gardeners for producing and retaining heat in pine apple pits, which purpose it effects without any mixture. Bark and leaves of trees require long time, and much mixing and preparation to reduce them to mould; hot lime will be the quickest solvent for fresh bark, and, the destruction of the fibre being effected, earths and dung may be added, which will bring the whole mass into a soluble and putrescent state. Hot stable dung has been used in the first application, in order to reduce the woody fibre; but caustic lime is stronger and quicker, and after the dissolution has been effected, the mild materials may be added, and the mixture completed. Time will effect a dissolution of the fibre without any mixture with the bark; but a long period will elapse, and it is usually preferred to break it up by hot applications. The reduced mixture may be used as a manure for any purpose, but chiefly for top-dressings, arising from its finely-divided and comminuted state.

Sugar-boiler's Scum is the skimmings of the vats during the process of boiling and refining it with bullock's blood and lime water. The albumen of the blood coagulates, and carries to the top the impurities and the dregs used as a manure. It is a very caustic substance, and suits well as a top-dressing on clay lands; the lumps are broken and spread thinly over the surface, and probably may be more economically applied by being mixed with earths and sand, and used unfer-

mented, at the rate of about thirty loads of mixture to an acre. The price is 4s. to 5s. a ton.

SAW-PIT DUST, and the shavings of wood, require much dung or vegetable refuse to bring them into a state of fermentation; but the best preparation of such substances will be obtained by being mixed in pits with blood, urine, and other liquid bodies, or in privies where they will be completely saturated. Sawpit dust is an excellent vehicle for night-soil, and when rotted in pits it may be used without mixture. and is very beneficial on clay soils in opening the tenacious texture of the land. The article will not often come into use, and the nutritious quality can be little or none, and can only act mechanically in the soil, or impart the qualities it has imbibed from being mixed with other substances.

The ploughing down and covering in the land of the crops of green juicy plants as a manure, is a practice of the ancient Romans, and is yet followed in Italy and other parts of Europe. This mode of fertilizing suits warm countries, where vegetation is very rapid and luxuriant; in colder latitudes, where the culmiferous productions are more the object of cultivation, the great utility of the practice has not yet appeared. The plants used for that purpose are the leguminous kinds, as tares, vetches, clovers, peas, buck wheat, and spurrey; and in Italy the harvest is early, and the crop is removed in time sufficient to allow the maturity of the green plants. Our climate does not allow such rapid successions, and a crop of any kind must be unprofitable that yields in return only what it has extracted, and leaves the land as before, in point of fertility. In order to apply the practice favourably, a very full crop must be supposed, and land that will yield a full crop of these substances will yield another kind of crop of more value. On poor lands a scanty crop may, and will, be expected, and a scanty crop will be of little service for that purpose, and almost invariably fills the land with weeds. Rape is reckoned to be very useful and efficient for the purpose, as it is of an oily and mucilaginous nature. Sorrel has been recommended to be cultivated, and to be ploughed down with lime, in order to produce a chemical combination; but very few soils will yield sorrel in abundance, and the chemical result may be too uncertain to justify the process.

The decomposition of vegetable matter "below" in the soil has been put forth in favour of this practice, and as producing soluble matter, and also mould, by a continued decomposition. The gradual decay of substances lying either above or in the soil, is certain; the fermentation of those that may be useful in promoting the growth of

vegetables is a very different question. Fermentation is a sensible internal motion of the constituent particles of a fluid, a moist, or a compound body, by which they are removed from their present situation and combination, and are again joined together in a new or different order or arrangement, forming new compounds, with very different qualities, from the original body or substance. It results from the combined action of air, heat, or moisture; and the first agent is oxygen, afforded either by the atmosphere, or by the decomposition of the included water; oxygen gas being absorbed, and caloric separated during the process, carbonic acid is one of the results, and fermentation is the natural process for reducing vegetables so a simple state of combination.

During putrefaction vegetables emit ammonia, phosphurreted hydrogen gas, and constantly carbonic acid gas, and hydrogen gas, impregnated with unknown vegetable matters. The colour changes to a dark brown, it swells and becomes heated, and is reduced to an earthy mass. The constituents enter into new combinations,—the hydrogen unites with the oxygen, and is either condensed as a fluid, or they assume a gaseous form, or vapour, which carries with it a portion of carbon. A part of this hydrogen unites with the azote in those plants that contain it, another remains in the putrid mass, giving it odour and colour. A portion of the carbon remains in the magma, another part unites with the hydrogen, and a third with the oxygen, forming with the latter carbonic acid. The brown mass or earthy residue contains the primitive earths, oils, metals, and salts, which are found in vegetables, forms vegetable mould, and becomes the principal means by which the earth receives back the principles it loses by the support it has afforded to vegetable life. In this process, air, heat, and moisture are indispensable, and a quantity of the substances must be laid together. Green or dry vegetables ploughed into the ground will lie in too small a quantity to generate heat; air and moisture will be necessarily excluded, and no active fermentation will happen to afford aëriform matters in the soil, as may be daily seen in the case of stubble and other dry substances. The conversion, by a gradual decay, is certain; but the activity for present benefit is wanting, unless an incipient fermentation has been effected previous to the application, to break the texture by a disintegration of the fibrous tissue. It may be very justly reckoned a wasteful practice to apply as a manure any substances that can be used as food for animals, and thus effect a double purpose: the second crops of clover and tares have been ploughed under for a manure, and, in that

case, the first crop must be cut early to allow the second crop time to produce a bulk of plants sufficient for the intended purpose.

If any of those succulent plants be raised as a manure for wheat, the bastard fallowing will dissipate the enriching matter, and if it be covered by the last furrow, the land must be in a very crude unwrought state, and it can only be reckoned a catch crop. The sole plausible case of application is on places that have failed to receive the due portion of farm-yard manure; but the season being occupied in bringing forward a crop for the benefit of the land as dung, wholly excludes any effective working of the soil, and, in any case, such unmanured lands may be partly wrought and sown with crops that will afford food to animals and also to the land, by the subsequent application of the excrementitious matter. The use of green crops as manures would not fail to constitute very foul farming; and though a successful isolated case may occur, an extension of the practice may not be expected. The green crops may be harrowed and rolled before ploughing, which will render them more convenient for being covered by the plough, and a compost of lime and earths may be added, which will also aid in covering the vegetables in the land, and tend to promote putrefaction. It may be supposed that in the countries where the practice is said to be so very beneficial, the soils may be more loose and crumbling, the vegetation more rapid and luxuriant, and the plants more juicy and succulent, and consequently more tender and easy of decomposition than in our country, and that a variety of circumstances may combine in rendering the practice very useful in some countries, and inapplicable in others. The plants should be ploughed into the land when they are in full blossom, and, if possible, in moist, warm weather; and the latter circumstance may form an advantage in favour of the practice in the warm countries where it prevails.

River Weeds, and weeds of any kind, and roots of weeds, make a very good manure, when decomposed by mixing with earths, and after the active vital principle has been destroyed: lime and earths will suit best for such purposes.

The refuse of pulp of pears and apples may be used with a mixture of mould, and along with leaves, and all decaying vegetable substances will make a very good addition to the dung heap. This pulp, or *pommice*, as it is termed in the cyder counties, will be apt to produce a number of young apple plants.

Vegetable manures may be most profitably used in a mixed state with earthy matters and calcareous substances; they will seldom

require a very strong caustic solvent, but the texture should be broken, and the disorganization commenced before the application is made to the land. In general practice the reduction is wholly completed, and the mixture forms a mass of cold earthy materials. Vegetable fibre differs much in plants,—being in some very flexible, and in others firm, and often hard and brittle. It is composed of carbon, oxygen, hydrogen, and a little azote; it is comparatively insoluble, and indestructible by spontaneous change, and has a toughness and elasticity produced by the stringy interstructure of the minute threads of its composition. When the substances are very strong and tough, hot lime may be applied to commence the dissolution, and earths and milder substances may be afterwards added to increase the quantity and quality of the mixture.

The reducing of vegetables to ashes by burning is attended with a very great loss of bulk; and though it be a fixed law of nature, that anything that passes through fire is a certain and powerful fertilizer; yet experience shows that "quantity" is indispensable, even though another mode of preparation be attended with greater present effects. They are transient in effect, and the quantity is limited, and they are also confined to local applications. But the use is great and undeniable in supplying the occasional want of the more substantial materials, and consequently weeds, and all vegetables must be collected by the farmer with much care and attention, mixed and reduced with earths and mild solvents, and applied as composts.

SECTION VII.—Mineral Manures.—Lime.—Its Nature and Composition.—Its Preparation.—Application on Turnip Fallows: Clay Fallows.—On Grass Lands and in Composts.—Quantity Applied.—Chemical Action of the Substance.—Magnesian Lime.—Description of it.—Use of it, not Hurtful.—Powdered Limestone not Calcined.—General Use and Description of Lime.—Gas-works Lime.—New Mode of Applying Lime.—General Remarks.

Of all the mineral manures lime first presents itself to our attention, both on account of the antiquity and the extent of its use. It is a substance, of all others, the most diffused over the earth, and, in the composition of animals and vegetables, it abounds in most places of the globe, forming vast regions of rocks and mountains, and in a great variety of forms and combinations produces materials of great utility to the purposes of human life. It forms a genus of the primitive rocks of geology, and is found in every formation up to the chalk, or the

most recent, and in formations above the chalk, with the siliceous and fresh water formations.

On the subject of the primitive formation of lime, various opinions have been entertained by speculative writers; some contending for an igneous origin, and others that it proceeds from the putrescence of marine animals, formed under water. It is the oxide of calcium, one of the newly-discovered terrigenous metals, with which we are as yet very imperfectly acquainted. Calcium has a great tendency to combine with oxygen, is four to eight times heavier than water, solid and white like silver, and, when heated, it burns brilliantly, and quicklime is produced. The very small quantity that has been obtained, and the very rapid combination of it with the oxygen of which it has just been divested, has rendered its examination difficult, and our knowledge of it very limited. Calcium combines with oxygen in the following proportions :—

Calcium, . .	20	or . .	71·91
Oxygen, . .	8	" . .	28·09

Common compact limestone is mostly floetz rock, and found in a state of carbonate, composed of about forty-four parts of carbonic acid, and fifty-six of alkaline earth. Quicklime has an acrid, pungent, disagreeable, and urinous taste, a corrosive quality, and a power of turning certain vegetable blues into green, and browning turmeric; and these properties indicate the alkaline character, and form a distinguishing feature. The alkaline earths are four: Lime, Magnesia, Baryta, and Strontia, and form a connecting link between the earths and the alkalies. They are dissolved in acids, yet not precipitated by the caustic volatile alkali (ammonia), but very readily by carbonate of potash, and this property distinguishes them from the other earths.

Effervescence with an acid is not a sure test of the presence of mild lime, as it will take place with carbonate of iron or magnesia; but when none is excited, it shows that no appreciable quantity of lime is present.

The proportions existing in pure chalk are twenty-eight of lime and twenty-two of carbonic acid. Limestones almost always contain other substances, varying in quantity from five to twenty per cent. The quantity of earthy matter in a limestone may easily be ascertained by introducing a known weight of it into cold diluted muriatic acid, and observing and weighing the part which, after twelve hours, refuses to dissolve, or exhibit any effervescence. It is to the presence of these foreign substances that limestones generally owe their colour, the pure carbonate being perfectly white.

Calcareous matters, in general, are neutral salts, or combinations of carbonic acid and lime, and are of many kinds, as chalk, spar, marble, shells, and concretions, differing in transparence, texture, and fracture, from quick or slow combinations, and from a subsequent exposure to a peculiar temperature. Lime is infusible in the strongest heat of our furnaces or burning-glasses, and yet it is a very powerful flux when forming mixtures with the other earths, which are all fusible with a proper addition of lime; a compound of three of the five earths may be fused to perfect glass, by being mixed in equal proportions, provided the calcareous earth be not excluded. Quicklime is nearly insoluble in water, requiring from 400 to 700 parts to dissolve it, and is not readily altered by exposure to the air; water saturated with carbonic acid, dissolves 1-1500th part of it, from which it gradually precipitates in the form of a white powder, as the acid leaves it. This powder is chalk; it effervesces violently with acids, and is almost wholly soluble in many of them; calcines in fire, but does not melt when in a state of purity, except under the combined influence of pressure and intense heat. Being so abundant in the form of rocks, or in combination with earths, and being slightly soluble in water, most springs of water contain it; and in various forms and qualities it is almost everywhere deposited.

Lime is obtained from the rocks and quarries by being bored and blasted with gunpowder, and then broken into small lumps by hand hammers. When it is exposed in confined heaps to a strong white fire above redness, water is expelled, and the carbonic acid gas escapes; a cinder or shell remains, reduced by one-third of the original weight, but without any diminution of the bulk or the hardness, and the lightness of the shell is a criterion of the quality, as the earthy mixtures do not lose weight by calcination. It should be removed immediately after burning, as it increases in weight by absorption; 100 parts of lime absorbing about 82 of moisture.

Good limestone contains sixty to eighty-five per cent. of carbonate, and in some instances as much as ninety-nine and a half; and though whiteness of colour is usually mentioned as denoting quality, yet it is known that some substances will alter the colour of lime without debasing the quality. But in general, good limes are white and light, and feel soft; while sandy and mixed limes are heavy and dull in colour, and feel gritty. When water is applied to lime in a newly-calcined state, a hissing noise takes place, a swelling follows, vapour arises, much heat is evolved, so as to ignite combustibles, and light is also emitted if the process be performed in a dark situation. The

sulphureous smell arises from part of the earth being elevated with the vapour, and the exhalation has the power of changing vegetable blues to green. Part of the water is evaporated, and the other combines with the lime and becomes solid, and the shells fall down into a powder of granular globules, and, when more closely inspected, of minute cubical masses. In this process the lime absorbs about one third of its volume of water, and is then called "slaked lime," or the hydrate of lime. By being reduced to powder from shells, lime increases in bulk about three-fold, and pure lime requires most water and time to become pulverized, and mixed limes are observed to require less. Cold water dissolves more lime than hot, a property not belonging to other bodies; water at 60° dissolves 1-770th part of its weight; at 138°, 1-972nd part; and at 212°, only 1-1270th part. After lying for a determinate time exposed to the atmosphere, lime imbibes a portion of carbonic acid gas, or the fixed air that was expelled by burning, and after being saturated with that gas, it returns to the same state as before burning, and becomes again mild lime.

The presence of moisture is essential to this process, for lime will not imbibe carbonic acid from a dry atmosphere, though present in large quantities, and hence the custom of keeping it long unmixed in a dry place. Consequently the time that quick lime requires to become a carbonate depends on the humidity of the air, and the quantity of carbonic acid it contains. The presence of any gases in the air will depend much on the climate and temperature, and also on the currents of wind that blow alternately in different directions.

In slaking lime a paste will be made if too much water be applied. To avoid this, give no more water than is required to produce pulverization. The water that combines with the lime parts with the caloric of fluidity, and also with the caloric in a state of ice; for if two parts of lime and one of ice be mixed at 32°, they combine rapidly, and the temperature is raised to 212°. Ice will slake twice as much lime as boiling water.

Limestone is burned or calcined in kilns or ovens of an oval or egg shape, and with different fuels, as fossil coal, peat, and wood, in alternate layers, with the limestones broken to a suitable size. When the undermost are burned, stones and fuel are added at the top, and the drawing away of the burned lime, and the adding of the fresh materials, goes on for as long a time as may be required. It is also burned in turf-kilns by farmers, who have the convenience of fuel and stone; but the carriage of the stone from a distance would be

heavy, and it is generally preferred to carry it in a calcined state. The chief advantage gained by burning is the expulsion of water and fixed air, which brings it to a condition to be reduced to an impalpable powder. Limestone may be over-burnt and vitrified, and become impure glass; such stones should be broken very small, so as not to require a very strong heat. All the varieties may be burned to quick lime; but during the process of rendering them caustic, many of them fall into a kind of sand, from the concretions exfoliating and separating during the volatilization of the carbonic acid—a circumstance that renders the use of them improper for the purposes of calcination. Trials have been made to use raw limestone pounded instead of being burned; and also to substitute the powder of calcined limestone, reduced by pounding, instead of the common way by slaking with water. But the results have not been accurately detailed, nor the preparations described. The expense of preparation must be much greater, and it is thought that the effects must be similar to dead lime, after it has been saturated with fixed air by long exposure, more durable, but not so quick as those produced by caustic lime. By pounding raw limestone, the benefits derived by the fire would be lost, which must be considerable, for burning unbinds the texture, and loosens every atom, and hence the effects of calcination in producing the finely-pulverized state of the substance. An equal weight of powdered limestone in a raw state will contain more than twice as much calcareous matter as when calcined.

Lime combines with the earths, oxides, and with sands; it forms the well-known mixture used as mortar in buildings, and with other bodies it constitutes many cements. This adhesive power of mortar arises from the strong affinity between lime and silica, and to the numerous points of contact presented to each other by the finely-pulverized bodies.

Lime has been most generally applied on fallows, or lands in a wrought and pulverized state; and has also been used by being spread on the surface of grass lands, and also in a mixture with earths, and then called composts. The application on fallow lands is the most general mode of applying it, as it affords the best opportunity of using the substance; and the period of the year also affords the most leisure and convenience for procuring and using it effectually. In the process of summer-fallowing clay lands for wheat, the soil will have been brought to the proper state of pulverization in the month of August, by four tillages, when the lime is brought to the field. By one mode the shells, brought fresh from the kiln, are laid on the land in heaps,

sometimes covered with earth, and at such distances as the quantity allowed to an acre may require, usually about one bushel of lime on a square pole; and when the air and rain have reduced the heaps to powder, men with shovels spread the contents evenly and regularly over the intervening spaces, and the lime is then covered by a double tine of harrowing, or by a ploughing, or by both. The putrescent manure applied to the land, if any, will be conveniently used after the harrowing, and before the ploughing, which will cover both dung and lime, and in which state the land will remain till seed-furrowed. By another method the lime is brought forward at convenience, and laid in large heaps in or near the field, and when fallen into powder it is spread by carts over the land in the allowed quantity, and covered by harrowing and ploughing. If the lands be not lying in permanent ridges and furrows, regular spaces must be marked by single furrows of the plough, to guide the spreaders, each of whom spreads over the included space, and thus ensures an equal and regular distribution. In the application of lime in the spring, for green crops, such as potatoes, beet, and turnips, the first mode is ineligible, by causing delay in the process of preparing the land; and the second is objectionable, as the heap contains hot lime in the inside, and dead, or effete lime on the outside, saturated by moisture into a paste, by long exposure, often coagulated into lumps, and consequently incapable of separation, and of minute application. If the heap be turned over before application, the objection will not be removed—for the heap will contain two kinds of lime in different states, and incapable of equal distribution. Both modes are faulty in exposing the lime too much before it comes in contact with the soil—and they are too dilatory for spring operations, wanting that systematic despatch which is the life and soul of all active operations. When the land has been brought into a proper state of tilth, and every weed and stone removed, the lime should be brought forward as near as possible to the time of application, and laid in a long narrow heap on the headland, rolled flat and level for the purpose. A day or two after it is laid down, water must be applied from a cart, and a man at each side of the lime turns the heap over, applying just as much water as will reduce the shells to powder, but cautiously avoiding to give a quantity so large as will run the lime into a paste or mortar. This point requires a nice attention, for a pulverization of the shell only is required, and nothing more. When this purpose has been effected, the lime should be immediately spread on the land, and harrowed in without delay, to prevent blowing by the wind. If the carriage of the lime be distant, the heap may be

covered with straw to prevent the dissolution, by exposing the lime that is first brought forward, and when the time of application arrives, the whole quantity may be turned over, broken up by water, and it will then be all of equal quality. In cases of very distant carriage, and other inconveniences, lime may be kept for a year in a state of shells, by throwing it into a high sloping heap, covered with straw, and when required it may be turned over, dissolved by water, and applied.

Though quickness of execution may not be so urgent in the application of lime on summer fallows as for spring crops, yet it is essentially necessary that the lime be applied, and incorporated with the soil immediately after being powdered; and on green crops in the spring it is usually applied on the pulverized surface, before drilling, which process, being repeated, reverses the drills, mixes the lime with the soil, and is further assisted by the subsequent hoeings and scufflings. A slight dose of lime is often laid on potato grounds just before the plants braird, with the view of its being mixed with the soil by the future operations of clearing and earthing the crops. From the stronger germ of the root and plant of the beet and potato, from their lying longer in the soil, and from not requiring so quick and immediate support from heat and moisture as the turnip plant, no damage can happen from applying the lime before drilling in any case—but in very dry seasons, a heavy dose of quick lime applied to land that is already void of moisture, just before drilling, when the turnip seed is sown, will absorb every particle of moisture—and if dry weather continues, a failure of the crop, at least from the first sowing of seed, will generally happen. But if the weather be moist, either before or after sowing, the objection will not exist: and it would be wholly removed, if the lime could be applied some time before sowing the turnips, that the land and lime may be mixed by the ploughings, and cooled by rain, and the attraction of moisture. In using lime on dry and hot turnip soils, it may be the safer mode to apply it to the barley crop, when it may be spread on the ploughed surface, covered by the subsequent harrowings and rollings, and no danger need be apprehended to the germ of the barley, owing to the coolness of the land, and of the season, and the greater frequency of falls of rain at that period of the year. Calm and dry weather are required in handling lime; and being in a very hot state in the above mode of application, the management requires a force sufficient to go on quickly, with a man or two to spread from each cart, and men to fill the carts at the heap, that the horses may be kept moving: a cart will finish an acre in a day, when the usual quantity is allowed to that space.

It has been recommended to mix lime with a large quantity of water, and form a milk of lime, and to distribute it over the land by means of a common watering cart. In places where lime is scanty, or procured at a great cost, this mode may be worthy of notice, as it is capable of distributing a small quantity evenly over the ground.

Lime has been applied to land almost from time immemorial, for the purpose of increasing the quantity of produce, and although we are yet very imperfectly acquainted with the process by which the action is exerted, or with the quantity that is required in different soils to produce the result, we know that it has the effect of liberating the ingredients of the soil, and of fitting them for the future support of the plants. "In order to dissolve finely pulverized felspar in an acid," says Liebig, "it would be necessary to expose it to continued digesture for weeks, or even months. But when the felspar is mixed with lime, and is exposed to a strong heat, the lime enters into chemical combination with the constituents of the felspar. A part of the alkali (potash) imprisoned in the felspar is set at liberty, and a simple treatment of the felspar with acid in the cold now suffices to dissolve the lime and the other constituents of the mineral. The silica is dissolved by the acid to such an extent, that the whole assumes the consistence of a transparent jelly." Most of the silicates of alumina and alkalies, when mixed with slacked lime and kept in continued contact in a moist state, behave in a similar manner to felspar when heated with lime. The clay is broken up by its union with the lime, and thus liberating from the soil the alkalies which are indispensable to the existence of plants.

Lime, from its solubility in water, can produce comparatively much less effect on wet soils, which in all cases should be thoroughly drained before any such application is made; on drier clays and loams it is thought to act mechanically in reducing the texture and altering the constitution of the soil. It may be supposed that in order to produce much effect in this way a large quantity will be required, much greater than is generally applied. The driest season should be chosen on wet adhesive soils, and the lime should be lightly covered and as minutely blended as possible with the pulverized surface. On sands and on the lighter loams lime is thought to be useful by its absorbent quality in retaining moisture, and consequently rendering the texture more compact and firm, a quality very necessary to be imparted to all loose and porous soils. Chemical analysis has shown that the exhaustion of soils produced by a repetition of scourging crops, arises from a diminution of the decomposing animal and vege-

table matters in the soil, and not in the earthy constituents; and hence the necessity, which is so much neglected, of applying to land the due quantity of farm-yard dung, and of not trusting to lime, or any other substance to supersede the regular application of putrescent matters. On all inferior soils, clays, loams, or sands, experience has most amply shown that a well prepared mixture of lime and earths is more useful than lime applied by itself, both for the first and for the future crops; for whatever may be said in favour of saline manures (and their value must not be depreciated in certain cases), in order to create, by any casual or temporary produce they may yield, the more durable vegetable humus in the soil, the fact is certain that a quantity and a bulk of materials is necessary to constitute a valuable application, and that where manures are wanting in this quality, a substitute or an auxiliary must be looked for, and quickly applied. So far as we know nothing will supply the place of *earthy* matters to add to the soil by future decomposition.

In regard to the chemical action of lime, the conclusions of scientific men, though no doubt they are correctly drawn and strictly true in relation to time and place, must yet be received with caution as to the practical use and application in the field. Covered by a roof and sheltered in the closet, the processes and conclusions of the laboratory are much too refined to withstand the tear and wear of field operations, and the change in the circumstances of application is so great as in some cases to destroy the whole relationship, and effectually overturn the inferences that have been deduced for practice. There is every likelihood that some of its operations are so latent and difficult of appreciation, that they have hitherto eluded the most searching scrutiny of the chemist. Lime alters the natural produce of the land by killing some kinds of plants and favouring the growth of others, the seeds of which had been lying dormant. It improves the quality of almost every cultivated crop, rendering grain brighter in colour and thinner in the skin, and the straw stronger and more reedy. It hastens the maturity of the crop by ten to fourteen days. Lime corrects acidity, and decomposes salts of iron, neutralizes acids, and renders them innocuous, which are not hurtful when they are chemically combined; but a consideration must be entertained for the uncertainty whether the substances will come in contact in sufficient quantity to effect the purpose; or if other agencies do not interfere to counteract the expected operations, as the quantity of a substance, and its quality and condition, completely change the nature and extent of the chemical action. Lime arrests the noxious effluvia which tend

to rise more or less from every soil at certain seasons of the year, and decompose them, or cause their elements to assume new forms of chemical combination in which they no longer exert the same injurious influence on animal life. The use of lime thus salubrifies as well as enriches a district; and when liming and draining go together, it is difficult to say how much of the increased healthiness and productiveness of the district is due to the one improvement, and how much to the other. How beautiful a consequence of agricultural skill that health and productiveness are at the same time promoted by its application! Can we doubt that the benevolent Author of all things hath placed before us this consequence as a stimulus to the application of other knowledge, in order to produce further improvements.

It has also been supposed that lime, by swelling and bursting with the heat generated by the absorption of moisture, breaks the tenacity of the soil by the fermentation, and renders the land more mellow. But the fermentation of any substance laid in the soil as a manure is very questionable; that such results happen when they are laid in a mass and enjoy the necessary agents is well known; but the case is wholly changed when the ingredients are separated and covered in the soil. Lime is hurtful when mixed with farm-yard dung by expelling *ammonia*, or when brought in contact in a caustic state with unreduced vegetable matters; it corrodes the substances, and tends to render the extractive matters insoluble; and it always to a certain extent diminishes the effects of animal manures by producing new combinations and arrangements. It converts unreduced organic matter into a mucus or mucilage, which quickly decomposes, unassisted; and though the lime does not afford direct nutriment to plants, it converts other substances into a state suitable for that purpose. The improvements effected on the coarse and sour herbage of moors and rough pastures by lime have been attributed to this property; but the quantity applied on the surface must be very great. On clays it reduces the adhesive properties by combining with other ingredients, and hence it acts as an alterative; but the application must be liberal, and the land well prepared for mixing. On sands it is thought to have a mechanical operation, and to give a consistency to the soil by combining with the finer particles, and attract moisture from the atmosphere. A cooling effect has accordingly been ascribed to lime on hot burning sands; but with some sands it will combine and form a mortar, and it may be proper in such cases to mix the lime with earths or clay. Our knowledge and speculations have led to the general conclusion, that lime acts both as an alterative and a stimu-

lant in rousing the dormant qualities of soils, moulds, and manures, and in changing substances into forms more favourable to vegetable life. The mechanical agency ascribed to it consists in rendering the texture of lands more open, porous, and friable, by mixing with the constituents of the soil.

A most erroneous opinion is very generally entertained, and has been very confidently promulgated both by practical and scientific men, that a kind of limestone that contains a portion of magnesia, is very hurtful to vegetation, unless it be applied in a mild state and in very small quantities. This limestone contains about twenty per cent. of the carbonate of magnesia, and forms in many places rocks of great height and extent. It is often called "Dolomite," from the French geologist Dolomieu, who found it in Mount St. Gothard and among the ruins of Rome. A sample from Yorkshire contains :—

Lime	29·5	Carbonic acid	47·2
Magnesia	20·3	Alumina and iron	0·8
Loss	2·2		

From Building Hill, near Sunderland :—

Carbonate of lime	56·80	Carbonate of iron	0·36
,, magnesia	40·84	Insoluble matter	2·00

Magnesian limestone abounds in many parts of England, and in Leicestershire it forms the curious isolated rock of Breedon, on the flat top of which is placed the parish church, surrounded by cultivated fields. It abounds in Ireland and in many places in England, and the analysis of it, as of other substances, varies in different places and from different experimenters. One more analysis may suffice :—

Carbonate of lime	68·	Carbonate of iron	1·
" of magnesia	25·5	Alumina	2·
Water	2·		

MAGNESIA, (so called from Magnesia in Asia Minor, where it was first discovered), is one of the nine primitive earths, and also one of the alkaline earths, and exists naturally as a constituent of several rocks and minerals, to which it imparts the soapy feel, forms a part of the saline ingredients of sea water, and the sulphate is an active principle in the natural saline springs, which are the resort of invalids. It is obtained from the sulphate, or Epsom salt, by dissolving the salt in water, from which solution magnesia will be precipitated by the application of potass: it is the calcined ley which remains after the preparation of nitre,—a soft light powder

with very little taste, and destitute of smell. when dry, it leaves a bitter sensation on the tongue—sp. gr. 2·3: tinges vegetable blues to green,—does not melt in the strongest heat: exposed to the air, it attracts a little moisture and carbonic acid very slowly, is not sensibly soluble in water, and has never been seen in a crystalized form. It combines with the acids, and forms several salts. Recent discoveries have found it to be the oxide of magnesium, one of the newly-discovered terrigenous metals, which, like silver, sinks rapidly in water, quickly absorbs oxygen, and is converted into magnesia. It is the most infusible of all the earths. dissolves in 1000 to 2000 times its weight of water, and retains a little water and becomes a hydrate. It has been found in a state of native hydrate, with 30 per cent. of water. Magnesia is composed of.—

Magnesium	60	—	Oxygen	40

Native magnesia contains:—

Magnesia	47·4	or	68·
Carbonic acid	51·	or	12·
A trace of iron	—	Silica	15·4
Loss	1·6	Sulphate of lime	1·6
		Water	3·

The stone found at Ferrybridge in Yorkshire, at Doncaster in Yorkshire, and at Breedon in Leicestershire, is most generally quoted as containing a very noxious quality, which was chemically examined, and the results detailed by the late Mr. Tennant of Cambridge. All the stones were found to contain nearly the same component parts,—about three of lime and two of magnesia. The magnesian lime in a certain time imbibed only 42-100th parts of fixed air, while common lime had imbibed four-fifths of its quantity: and to this non-absorption, and the consequent remaining of the magnesian lime for a longer time in a state of causticity, the noxious quality has been attributed.

In all matters that are purely philosophical, minute accuracy is not only very desirable, but absolutely necessary; but, in practical arts, such as agriculture, it is wholly unattainable. The circumstance of the experiments being made in cups and pots, and in a room warmed by fire, is nearly sufficient, of itself, to nullify the whole process: for no certainty or probability existed of the soil and lime coming in contact, in the same state and quantity, as in the cases mentioned: and unless experiments, from which are to be deduced practical applications, be made under the same circumstances and in a tangible form, they can only be regarded as facts in that particular state, time, and place; but affording no safe grounds for the expectation of similar

results, when exposed to agencies which exerted no influence on the first determination. Lime may be taken from the kiln in the hottest state, and powdered by the application of water, and immediately laid on land, and ploughed in and mixed, and crops sown; and, except in the single case of turnips in a dry season, before or after sowing, not only no damage ensues, but very great and beneficial results follow the application. In that case, the lime is in a state as caustic as can be found,—and the mode of using it is the most economical and most approved. Prodigious quantities of magnesian lime are burnt at Sunderland, and carried to great distances coastwise both north and south, and no complaints were ever heard against the use of it, and it is applied in very large quantities. It is even hard, or rather impossible, to conceive how thirty, or sixty bushels of lime,—the quantity said to be hurtful,—can prove injurious to an acre of land, when spread regularly over it, and so much divided in particle and in quantity; or how that quantity of any substance that is known to be the most hurtful to vegetable life can effect any damage when spread over so much space, and mixed with the soil, and so much separated and divided. It might much more readily arise from improper management or unequal distribution.

Having been personally engaged in the cultivation of lands in the neighbourhood of Breedon rock, in Leicestershire, I had occasion to use considerable quantities of lime, and consequently had a fair opportunity of proving the quality of that rock for agricultural purposes. The lime was brought forward in shells hot from the kiln as usual, and laid in a long heap on the headland, turned over and powdered by the application of water, and laid immediately on the land at the rate of two hundred bushels on an acre, and harrowed in as applied. The lime ran from the carts like quicksilver, and was certainly as caustic as it could be obtained. The land was immediately drilled, farm-yard dung applied, and planted with potatoes, beet, and turnips, in their respective seasons. On one field a double allowance, or four hundred bushels an acre, were applied as an experiment, to test the noxious quality of the lime. In every case the application was attended with the very best success, and, for several years, the green and culmiferous crops were excellent, and on the ground where the double allowance was applied, the crops of wheat and of hay showed a great superiority, which was very visible at a considerable distance. Here was no damage from magnesian lime, but very great benefit,—yet the results convinced few persons, for the current of prejudice ran strong. Many bad qualities have been ascribed to magnesian lime,

as killing vegetation and promoting the growth of couch and other weeds. Manures of any kind will stimulate the growth of weeds as well as of cultivated plants, but it is the business of the farmer to have few or no weeds on the land to extract the nutriment he has provided for the increase and maturation of the crops. For, in farming, as in gardening, nothing should grow on land except what is sown: and, though that degree of cultivation may never be attained, as there may ever be a wide difference between possible and ideal excellence, yet the nearer we can approach to it the nearer we approach to perfection.

Lime, both in a hot and effete state, has been applied on grass lands, and in some places with very good effect; but, as a mode of general application, it is not to be recommended. Like other substances that are applied as manures, it banishes the coarser herbage, and a finer succeeds; and it is stated by experienced agriculturists that clover follows the application of lime on grass lands where none had been observed before. On wet lands, however, in high latitudes, and in humid climates, the effects are very uncertain. A very economical and beneficial use of it has been found in mixing it with earths, in quantities of each substance, generally known by the name of composts. Great quantities of very valuable manure may be got by this method; for clays, sands, and earths of all sorts, which may be got from the road sides, and old fences and ditches, and other similar matters, are all available for this purpose. The materials will be in a very rough form, and the lime must be mixed with the heap of earth in the very hottest state, in order that it may break the texture, and reduce the particles of the coherent mass by the bursting and crumbling which will take place, by reason of the generation and evolution of heat and the absorption of moisture. The heap must be repeatedly turned over, and the lumps broken as small as possible; and in order the more fully to promote this purpose, a second application of lime may be necessary, if it be seen that the first has not sufficiently pervaded and crumbled the mass. Fineness of pulverization is indispensable, and to promote that purpose an ample dose of lime is absolutely necessary, with frequent and careful turnings of the heap. If the substances be of a loamy and a vegetable nature, and contain any organic matter in a comminuted state, no powerful solvent is required. Lime may be applied in a small quantity, or in a mixed state, so as not to destroy or dissipate the vegetable matter; or the heap may be dissolved or decomposed by turning and exposure, and the lime may be mixed immediately, or a short time before the application to the land, with the view of stimulating or quickening the

vegetable matter. But if the materials be of a clayey and harsh nature, and lie in a very rough and unbroken state, a very large allowance of the hottest lime must be used, in order to overcome the tenacity and prevent the future adhesion, and also to alter the nature and character of the mixture. Great neglect yet prevails in collecting and preparing these composts, an unprofitable parsimony in not allowing a sufficient quantity of lime, and much negligence in turning over and reducing the heaps to a sufficient fineness of mixture. Two bushels of lime to a cubic yard of earth has been mentioned as a suitable quantity for mixing together; but no certain rule can be laid down in such variations of different qualities. When the heaps have been reduced and mixed as much as can be effected, the compost may be laid on grass land in the early spring, at the rate of about forty loads an acre; and when dried by exposure, the bush-harrow must be applied to break the clods, and followed by a heavy roll, which squeezes every clod, and levels the irregularities. Benefits are supposed to be derived by harrowing mossy swards, before laying on the composts, with instruments provided with square and scimitar tines fixed alternately, and by tearing the mosses and making ruts in the land, to facilitate the mixing of the manure in the soil. Such remedies are very superficial, when grass lands have got into that mossy state; the only effectual cure is to break it up and improve it by means of manure and tillage, and relay it with fresh grass seeds. On hay lands, the crops are much benefited by good composts; and on foggy pastures, the quantity and quality of the grass may be very much improved by a liberal application of well prepared composts, and by subsequent depasturing by sheep. Composts are equally useful on fallows, and are more certain in effect on all inferior lands of any description, than an application of lime singly in any common quantity.

It has been proposed to lay lime on fallows, and on lands ploughed from grass for crops, by making heaps of alternate layers of hot lime in shells, and the clods and lumps of rough fallows, and also with the furrow slices of grass layers, ploughed lightly for the purpose of being so reduced. The heaps should be raised to a convenient size to be watered from a cart, and in the dissolving of the shells the earth will be pulverized and blended with the lime; the pulverulent mass will be spread on the surface, and incorporated with the soil in fallow;—or in the case of burning the grassy sward, the land will be ploughed for crop. This process will be very effectual in reducing stubborn fallows that very often defy the efforts of labour, and will add both

lime and ashes to the soil; but the land must be wrought to a certain degree before it can be accomplished, and the labour required may be considerable. In certain cases, it will constitute a mode of most valuable improvement. On grassy swards, the dissipation of the vegetable matter by the fire will be urged in objection; but the effects of the fire can be moderated. No flame or violent burning will arise from the moist smothering effects of lime being slaked; and as a preparation for oats, and more especially for wheat, either on a summer fallow or on a grass sward, it might prove very beneficial. For the latter crop, the later season would afford a better chance of the work being properly executed. Little notice has ever been taken of this mode of applying lime, and of preparing land for crops; but on all rough fallows of any denomination, no doubt can exist of the profitable utility of the method, both in providing manure for the land and in reducing the texture. And where occasion suited, it might be advantageously employed in preparing grass swards of the poorer sorts for grain crops; and the turfs on land prepared for burning might be scorched or torrefied with lime-shells, in places where the practice could be adopted from the price and convenience of the lime. The effects of lime mixed with the ashes from paring and burning have not been satisfactorily ascertained; but, probably, a combination of different efficacy would be produced by the combustion and more intimate mixture of the substances. On this point, no trials of sufficient authority have been recorded; where lime abounds, the burning or scorching of the turfs would go on in damp weather, which is often very baffling in wet seasons by the common mode or process. In Germany, the lime is laid in long narrow heaps on poor lands, when the soil is laid on it as it is slaked, and impregnated with the vapours arising from the lime, and without being mixed with it. The earth is then separated from the lime, and found to contain very enriching properties, and produces a most luxuriant vegetation in all plants that are exposed to its influence.

No position in practical agriculture is now more universally acknowledged, than that the existence in the soil of animal and vegetable matters forms the character of the land in point of barrenness and fertility; and our experience in the use of lime also shows that the effects of it are greater or less, as the quantity of these matters is abundant or wanting. In the case of old arable lands, the matters are often exhausted by a too constant repetition of the culmiferous crops, and must be again supplied and restored to the land in the shape of dung, to fit the soil for the action of the lime. The great

value of fresh vegetable turf has been long acknowledged and acted upon by the turnip farmers in the northern parts of the kingdom, where the success of all crops, especially that of the turnip crop, is ascribed to the benefits derived from the decaying remains of the vegetable turf produced by the rotation of alternate cropping and pasturing. This fact was particularly observed and pointed out in the Survey of Northumberland, more than fifty years ago, by Messrs. Bailey and Culley, two of the most enlightened cultivators that Britain has ever produced, where it is stated, that "the turnip crop seldom succeeded unless the seed had the freshness of a lea clod to vegetate it." All practical men agree in the advantages to be derived from this vegetable freshness, and, this being the case, it seems a very natural inference to expect that means would be used to produce it for the benefit of the subsequent crops. But, over the greater part of Britain, the practice is the very reverse; for a part of every farm is used as arable land, and ploughed and cropped in constant succession, and the organic remains are thus completely dissipated. The other part is kept in old grass turf, where the herbage is generally in a state of constant decay from an excess or want of water, and no opportunity is afforded of giving to or deriving from the land, the advantages of cultivation and of a change of plants. If we admit the theory of noxious fecal exudation, it must be pernicious to have lands constantly producing the same plants; but the great advantages derived from a fresh vegetable turf for the use of the subsequent crops, rests on no unconfirmed theory; and, after the profitable experience of three-fourths of a century, the system needs not at this day any reasoning to support it.

Thus, by one part of our practice, we dissipate, by means of too constant ploughing and cropping, every vestige of vegetable remains, and that in opposition to an established fact, and even of positive conviction; and, by the other part, we accumulate a vegetable turf, and lock it up and render it useless by means of prohibitions and restrictions for the purpose of future development. In the former case, the land is unable to derive the benefit of manures and of lime, from the want of reciprocal affinity,—whence arise many of the failures of lime; in the latter case, the land lies, in many instances, a lasting monument of ignorance and prejudice, without profit and without utility. No manure yet known can effectually supply the place of the vegetable turf and freshness, especially on inferior soils, and in inland situations where manures are scarce: on good lands and where manures are more plentiful, the use of it may be supplied in a greater

degree; but no application we can make will, in so short a time, reduce manures to the same comminuted and finely blended state, so favourable to the action of fertilizing substances and to the growth of plants. On this point of most vital importance, science and practice are most fully agreed.

In the preparation of gas for the purpose of illumination, a quantity of lime is used to purify the coal gas of a part of the sulphuretted hydrogen, with which the lime combines, and becomes a sulphuret or a hydro-sulphuret of lime. It is very soluble in water, and has the smell of sulphuretted hydrogen, with a bitter pungent taste. On exposure it is reckoned to become a sulphate of lime, by absorbing oxygen and parting with the hydrogen. The conversion into gypsum will be no recommendation in the present opinion of that substance. It sells at 7s. 6d. per chaldron at the gas works, and may be applied by itself or mixed in a compost, when, in addition to the usual effects of lime, it may exert an influence on noxious insects from the possession of the gaseous matter. The limited quantity will render it a manure of secondary importance.

We have enlarged on the use of lime, but the great importance of the subject must plead our excuse for giving a few more general remarks.

On the use of lime in a hot or in an effete state, opinions are divided, as equal benefits have been derived from both conditions, probably arising from peculiar circumstances in the application. But the hot powdered state is in general to be preferred, as the lime is then in the most pulverulent and minute condition, and ready to enter into new combinations, and to convert into manures any suitable substances it may find in the soil. It is an indispensable requisite, and of the very last importance, that wet soils be thoroughly dried by draining before the lime is applied, and that it be used in dry weather and in a dry season of the year. The application of lime in autumn is not to be recommended, owing to the solubility of lime in water, and the want of the summer heat to develop the action of the lime on the substances in the soil. Caloric must be held as one chief spring of chemical affinity: it dilates bodies, separates the particles, diminishes the attraction for each other, and proportionably augments the attraction of the particles of adjacent bodies, and consequently produces combinations and facilitates reciprocal unions. The winter will chill the operations, and at that time there is no growing crop to derive any present benefit. The preferable application is on fallows in spring or in summer, used expeditiously and blended with the soil in a finely reduced state, and on barley lands, and harrowed

in on the surface when the land is ploughed in the spring. The unmixed application of lime on grass lands is not generally advantageous, though it has been attended with very beneficial effects in many instances and on different soils. It is liable to be washed away by rains end hardened into particles, which sink to the bottom of the furrow when the land is ploughed for crop. A well prepared compost, as above described, is much to be recommended on grass lands, either for the purpose of renovating the grass, or before being ploughed for grain crops: in the latter case, the composts should be applied some time before ploughing, in order that the manure may raise a sward of grass, which will decompose and afford nutriment to plants. On this sward the future crops will depend,—for, where there is vegetable matter, other crops will follow. Lime increases the quantity, and is also thought to add to the quality of the grain; the straw is more reedy, bright, and clear, and the grain is more farinaceous, from the lime tending to convert the mucilage into starch. Being reduced to a finely pulverized state by calcination, it requires the soil, if possible, equally well prepared with itself, for between a variety of finely blended ingredients, there will be produced a number of reciprocal actions and affinities of the different parts that would not happen in a smaller quantity of these substances in a more aggregated and cohesive state. The quantity of lime applied is almost ever too small the evidences of nature and of art in favour of a more liberal allowance are overlooked, and much labour and time and money are mis-spent, in carrying from a distance a "dusting" of lime to a field of unwrought rough clay lands, where the application has the sole effect of gilding the clods with a whiter varnish than they before possessed.

Hot lime must be very cautiously used in being brought into contact with fresh and unreduced vegetable and animal substances; it may be applied at a more advanced stage of the decomposition in a moderate quantity, or in the usual quantity, but in a mild state. Clayey substances, tanner's bark, and all strong fibrous materials, and similar bodies, will require a powerful solvent, and lime may be used in the hottest state, in order to break the texture, and change the composition; but with decomposing matter in a more reduced state, it will corrode and dissipate the organic elements, and consequently may be used sparingly, or in a mild state, before the application to the land. Lime in mixture with farm-yard dung is seldom used, as it is generally reckoned hurtful, and the only extensive use of it in mixing with other substances, is with the earths, the earthy aggregates and compounds. The effects of lime, and of all other manures, are in a

direct ratio with the quality of the soil itself; and though there will be exceptions to this rule in the case of lands fresh with vegetable matters, yet experience teaches us, that the effects are much greater, and more certain, on deep clays and loams, than on the poorer sands and clays of any denomination. Lands that have been long under tillage, and consequently exhausted of organic remains, should be brought into a proper state for the action of lime, by a liberal application of putrescent manures, and by a judicious and enriching course of cultivation. The farmer who would advance safely and prosperously in his business, must study the processes of nature in fertilizing the earth. No substance yet known to us, will supply the want of animal and vegetable matters, and if they be wanting in the soil, they must be supplied in the shape of dung, and by an improving course of cultivation, if we wish lime to be profitably applied. The farmer who does not know how to improve by such methods which are in his power, is ignorant of the first principles of his business, and is only capable of impoverishing his farm and ruining himself. On good clay lands and on deep loams, the allowance of lime should be very liberal, and on poorer soils the farmer must consider if he has prepared the lands for the action of the lime, by draining, in the first place, if wanted, and by thorough working and fallowing, and by a continued application of putrescent substances—and if he has improved the quality of the land and retained these substances in the soil by judicious cultivation.

A new method of preparing lime for land, consists in breaking the crude limestone into very small pieces, which are thereby easier and more uniformly burnt, and carrying the hot shells from the kiln, and spreading them on the land, where they burst and dissolve, and are mixed in the soil by the subsequent ploughings and harrowings. Benefit is supposed to be given to the land, by the moist heat and damp exhalations evolved during the dissolution of the lime shells. This method of using lime merits the attention of the farmers.

SECTION VIII.—Chalk—Gypsum—Mud—Soot—Bleachers' Ashes—Soap-boilers' Waste—Coal Ashes—Coal Tar—Salt—Nitre.

Chalk is a calcareous earth, and the most recent formation of the carbonate of lime. It is divided into chalk marl, hard chalk, and soft chalk, and rests on the third sandstone formation. The first species is not very abundant, but it occurs in Oxfordshire, Kent, and Sussex. The second, or indurated chalk, forms the stupendous cliffs of Dover

and Flamborough Head, and occurs in some places in Ireland. It is harder than the upper formation, and is frequently of a red brick colour, and contains a few flints and petrifactions. Soft, or upper chalk, which is the substance commonly used, and along with the hard chalk occurs stratified, sometimes horizontal, perpendicular, or with an inclination of the strata meeting each other, and the former often resting on the vertical. Iron pyrites is the only mineral found in the chalk formation, and that very sparingly.

This mineral is very rare in Scotland, but abundant in large tracts of country in the south of England, and in the north of France, as well as in the northern countries of Denmark and Poland, and in some parts of Russia. In England, chalk is often found of sufficient hardness to be used as building stone; it also endures fire well, and is used for grates and chimneys. Recent examinations of chalk by microscopical observation have led to the conclusion that it is composed of animalcules, varying in size from 1-24th to 1-288th part of a line. A cubic inch contains upwards of a million of them, and consequently a pound weight of chalk will contain above 10,000,000 of these animalcules. It will be a most curious fact, if fully confirmed, that animals invisible to the eye, and yet possessing all the functions of vitality and perfect organization, should be able, in the course of centuries, to exert an important influence in modifying the crust of the earth, and to impose the present character by forming mountains and changing the face of continents, and also to give a direction to the labour and industry of man. Masses of many hundred feet in thickness, thus singularly composed of animalculæ, constitute one of the most striking discoveries of modern science, and the flints imbedded in the chalk are supposed to be similarly composed, and to have been once alive. The vast beds of the oolite formation, which yields the Portland, Bath, and other free-stones, are similarly constituted, and by affording materials for the hammer of the mason, and the chisel of the artist, exhibit the phenomena, that we are actually building our palaces and temples with the skeletons of creatures which have existed in the primæval eras of our earth, and which, after having fulfilled the functions of life have been destined by the Creator to furnish materials for the solid strata of the earth, and to contribute to the comforts and enjoyments of the human race. Chalk contains :—

Lime	56·5	or	53·
Carbonic acid . .	43·	,,	42.
Water . . .	0·5	,,	3·
Alumina	—	,,	2·

Chalk is converted to several uses: it is used in a rough state, and cut and polished for building stones; it is burnt into lime and used as mortar, and also in polishing glass and metals; for whitening plasters, and in the construction of moulds for casts. It is used in mixing vegetable colours, and with the white of eggs forms a fine cement. It is adapted for filtering-stones, and in a refined state is used as a remedy to correct the state of morbid acidity in the stomach. It absorbs five times its weight of water.

Hard chalk is burned in kilns and calcined for the powder, in the same way as limestone, when it loses about four-tenths of its weight; and some of the most eminent engineers and architects have reckoned it fully equal to limestone for mortar, though the general opinion of farmers and builders suppose it to be of a weaker nature, and to require the application of a greater quantity. But in several places chalk lime is preferred, though good limestone abounds in the vicinity. In the southern counties of England, where chalk chiefly abounds, it is burnt in flame-kilns, by means of faggots or the refuse of the cuttings of woods and hedges, and the quantity of 1000 faggots is allowed to burn a kiln of 600 to 700 bushels of lime. Where fuel is abundant, the common limestone kilns are used, and the calcined materials are in every way treated as lime in the application to the land.

The soft chalk, which is dug from pits and laid on the land in a raw state, is of a much softer and more friable nature, and is exposed for a time to the action of the atmosphere, in order to reduce it to a state sufficiently fine to be incorporated with the soil. The most approved mode of application recommends the laying of the chalk in small heaps, from the carts, on a summer fallow, or on a clover ley, or a stubble intended to be sown with wheat. It should be dug from the pits in autumn, and laid at once on the land intended to be dressed with it; the rains and frosts will be useful in pulverizing it, and what is left unreduced must be broken by means of axes and hammers. Some considerable attention is required in getting chalk properly pulverized: the fat unctuous kinds soon crumble on exposure to the air, but the harder sorts require trituration or a long exposure. Chalk is often found by opening pits in the fields, and is carted over the land as it is dug, but very few situations admit this mode of application; and on clays and sands, where it has proved most eminently useful, chalk must be carried from the neighbouring pits, or from pits opened in some convenient place. The quantity allowed to an acre, like many similar applications, varies much according to local circumstances—the state of the roads, the cost of the article, the state of the

land, and the fancy of the farmer. Reports state 100 to 1000 bushels, and a medium may be taken at forty or fifty cart-loads, or from eight to fifteen loads of a wagon. The expense of carrying and applying any raw or crude material ever prevents its extensive application, for a long land carriage of a heavy article is wholly beyond the reach of agriculture.

Powdered chalks, like limes, reduce the texture of adhesive soils, render them more open, porous and friable, mixing with the particles of the soil, and preventing the future cohesion. But this effect supposes a state of the land somewhat or nearly approximating to the state of the chalk itself, or the finer body can never get mixed with the more massive, so as to produce the results expected from the affinity of combination. In order to produce this change in the soil, and that it may be effectual and permanent, there will be required a large quantity of the acting substance that is applied, and a suitable preparation of the soil, as well as of the substance itself, in order to promote the reciprocal action. On strong clayey lands, and on clayey loams, chalk has produced very great effects, not only on the immediate crops, but lasting for a number of years, rendering the soil looser and easier of tillage, and more favourable to the action of other manures. Contrary opinions have been expressed, as may be expected on such points, from a difference of circumstances. Chalk is said to be an enemy to good grass, and to destroy white clover on lands where it grew before, a statement so contrary to the generally received notions of the action of all calcareous substances, that, though it may be said we must not argue against experience, yet the partiality of the experiments, and an opinion perhaps hastily formed, without duly weighing the peculiar circumstances of the application, may be allowed to extenuate the force of the evidence. On wet, sour lands, chalks have been observed to banish acidity, by the disappearance of rushes, sorrel, mosses, and other coarse plants that grow on such soils; but if the wetness and sourness be very powerful, it will require draining to effect a lasting cure, though in cases of less prevalence, an application of chalk may do much in removing the evil. On all dry soils of a lighter description, sands, loams, gravels, and even light chalky lands, very great improvements have been effected by large applications of chalk, the effects of which have not ceased with a few crops, but have operated, as all calcareous substances do, in imparting properties to the land that it did not before possess, and at the same time increasing the quantity of every crop of the produce. On hot burning sandy lands,

an application of chalk is very beneficial in retaining moisture, and by that means correcting the too porous and friable quality of the land. Powdered chalk exerts a cooling influence from its strong affinity for water, from presenting a more extended surface to the air and to the particles of the soil absorbing moisture from the atmosphere, and retaining and giving it out regularly and uniformly to the roots of the vegetable crops. On sour pastures, an application of chalk has the usual effect of diminishing the quantity of the coarser grasses, and bringing in their place white clover, and a finer and a sweeter herbage. The observations of the best practical men always show the superiority of good composts of calcareous substances,—as chalk and lime with earths and moulds,—as supplying earthy and vegetable matters to the land, the want of which constitutes the great defect in all inferior lands.

Crude chalk is a mild agent in its chemical character, and like uncalcined lime, possesses none of the destructive solvent qualities of that body after it has been subjected to the action of fire. It is said to promote putrefaction, and an opinion prevails that the effects are wanting on calcareous soils, and that the benefits are proportioned to the absence or presence of those substances in the land. Sands are also said to have been hurt by frequent chalking, and by applying beyond a certain quantity. This result is also the supposed effect of frequent liming, and both cases may be reckoned equally doubtful. The chemical action of chalk lies in absorbing moisture, and by attracting acids to hasten the putrefaction of vegetables; the mechanical effect is produced by its mixing with clays and converting them by a proper pulverization into a species of marl, by entering into the composition of the land, so as to prevent the stubborn hardness in summer, and the wet adhesiveness in winter. The use of chalk is a very ancient custom, for Pliny has related that the ancient Britons used it, and found very great benefit from it in fertilizing the land. The fat, unctuous, earthy kinds are most suitable for use in the raw or crude state, and the hard, dry, and firm kinds are the best adapted for burning into lime.

The effects of manures of all sorts depend much on the quality of the land to which they are applied, and also to the state of preparation of the soil at the time when the substances come in contact with each other. Finely reduced and pulverized bodies cannot mix with those of a grosser form,—masses, clods, and lumps, either of homogeneous or heterogeneous substances will lie together and remain in the original state of cohesion or aggregation, but no affinity of composi-

tion takes place at sensible distances, and consequently no results follow from the combined influences of the bodies in union. The contact of a pulverized substance with a mass or gross formation cannot produce the effects of combination, the finer particles of the former touch only the external surface of the latter, the interior parts remaining unaffected and unavailable for the purposes and effects of alteration. Hence, the necessity of reducing such substances and the land itself to as fine a state as possible, lumps of chalk may be laid on fine soils and mixed by means of ploughing, without being pulverized, rolling will press them into the land without breaking them; but the intended purpose will be defeated, unless the chalk be ultimately blended and mingled with the soil at the first application. In all cases, therefore, chalk must be finely reduced; on stiff clays and loams the allowance must be liberal, on thin, poor soils of all denominations, a compost of pulverized chalk, with earths and moulds, is a surer application than chalk alone; the land must be kept in constant possession of decomposing animal and vegetable substances, by the frequent application of putrescent manures, and by a judicious and ameliorating system of cropping, in order that the calcareous substances may have the means of active union presented to them; and land so managed with any of our known manures, will not often disappoint the expectations of the farmer.

GYPSUM is a calcareous formation, or limestone in combination with sulphuric acid, and abounds in the flœtz rocks, though rarely found in the primitive or transition class. The beds rest on the limestones, plastic clays, and sands, in some places 60 feet thick, irregularly prismatical, granular, foliated; contains fluoride of calcium and small bones of quadrupeds, and some fresh-water shells, being often intermixed with, and passing into, the rock of limestone on which it rests. Common gypsum contains six sub-species, some of which are transparent as glass, and used in stucco, and others take a good polish and are cut into crosses, necklaces, statues, columns, vases, and plates. The kind of gypsum called plaster of Paris is composed of gypsum and carbonate of lime, in the proportion of 83 to 17, or:—

Lime	32
Sulphuric acid	46
Water	22

The Greek writers inform us that the ancients used gypsum to clarify their new wines by throwing it into the liquor, and then pouring it out after remaining at rest for some time. The wine

acquired a sharpness which it afterwards lost, but the good effects were otherwise lasting. The custom is not yet wholly disused, though expressly forbidden in many countries. But it has been doubted if our modern gypsum was that of the ancients; we know that they burnt their gypsum and cast images of it, but what substance they meant by that name, our commentators have not been able to determine.

Common gypsum is found in great quantities in the counties of Derby, Notts, Leicester, Gloucester, York, and Stafford, and also in France; the Derby gypsum is of great variety, and has not yet been accurately described by any competent geologist. The colour is commonly grey, red, and white, seldom brown, yellow, or black. occurs massive and disseminated, also in granular and prismatic concretions, sometimes crystallized in small conical lenses, with a rough surface, pearly, and passes from shining to glimmering, cleaves like selenite, fragments blunt, edges translucent, sectile, and easily frangible; contains:—

Lime	32	or	32·2
Sulphuric acid	30	"	45·8
Water	38	"	22·

Gypsum dissolves in water with nearly 500 times its own weight, and with a mean temperature, and nearly equally in cold or warm water, and the solution produces a few crystalline grains, but no crystals, has little or no taste, and is not altered by exposure to the air, does not effervesce with acids, nor is decomposed by any of them except the sulphuric, and that solution is decomposed by water. When gypsum is heated it loses the water of crystallization, and is called plaster; when mixed with the carbonate of lime, it forms a very good cement, but with sand or clay, it is of a very inferior quality.

After the water of crystallization has been expelled, gypsum becomes opaque, or falls into a white powder, absorbs water very rapidly, and becomes hard. It is almost infusible without addition; but selenite appears to undergo a partial vitrification when exposed to intense heat, and also to lose a great part of the sulphuric acid, as is evinced by the penetrating smell. It fuses into a white glass, but soon falls into powder. When heated with charcoal, gypsum is converted into sulphuret of lime. Gypsum is more loose and friable than limestone, effervesces very slightly, either crude or calcined; and does not effervesce or is decomposed by muriatic acid, except it be impure. Specific gravity, 1·872 to 2·311.

Powder stones are calcined in kilns, or heaps of the stones loosely put together, with vaulted pipes or flues. The heat must be moderate, to prevent extreme calcination, which would deprive the plaster of its quality of forming a solidness when mixed with a certain quantity of water. The water of crystallization will rise in a white vapour, which is soon dissolved in a dry atmosphere. The powder is prepared by pounding the calcined fragments by machinery or by hand, and then adding water in the necessary quantity to produce the plaster. The dust is said to be very hurtful to respiration.

It would appear from the writings of the ancients, that some substance similar to gypsum was used as a manure; but we find no mention of it in modern times, till about the middle of the eighteenth century, when it was brought into notice by M. Meyer, a German clergyman, who made trial of it as a manure with much success. The flaming accounts that were published of the prodigious effects of that substance as a fertilizer soon spread over Europe: and in America the use of it has been very extensive, being imported from France and carried inland to great distances, before it was discovered in a native state in different parts of the importing country. Too much benefit has ever been held out as certain of being realized from similar discoveries and applications; how utility is affected by time and place, and limited by certain uncontrollable causes, is generally overlooked; and in most cases, a short time soon reduces magnificent expectations to the standard of moderation and of the just hopes that are warranted by sound experience. In the first place, the idea of raising and supporting fertility by means of saline substances, is sufficiently contradicted both by science and practice; and in the second place, the action of these substances is influenced by causes to us unknown, and very probably uncontrollable. In America it has been used at the rate of two and three bushels an acre on wheat, when the crop was nearly doubled; on clovers the crop was trebled, and it was found, or probably rather supposed, that six bushels were superior to fifty loads of farm-yard dung. These results issued from the sanguine press of the first introduction: a more extensive and varied practice soon limited the benefits to particular crops, soils, and situations, and the most decisive trials made on different crops and soils, and in the quantities of one to twenty bushels on an acre, proved very unsatisfactory, and even conclusive against the use of gypsum, under the circumstances of application. In that country, no difference is made between native and imported gypsum, as to quality. For benefiting clovers and grain crops, and for turnips, and similar plants, it has

been much recommended; but in all the trials, on any crops, the failures much overbalance the success.

Gypsum is prepared by reducing it to powder by breaking it with sledge hammers, and by grinding it to a coarse meal; it is then sifted, and yields about twenty-five bushels to a ton, according to purity, and the finer it is reduced, an equal quantity will have the more effect. It costs at present £3 a ton. It is seldom calcined for manure, which can only reduce the weight by expelling the water, as the sulphuric acid is not evaporated by the strongest heat of the furnace. No difference has been perceived between the effects of raw and calcined gypsum on experiment; but the latter rapidly absorbs water, and becomes hard and forms a paste, and the only effect of calcination must be, to bring it into a finer state of powder, and render the carriage cheaper. The most approved mode of application recommends the sowing of it on clovers and young grasses, and on all leguminous plants, in the quantity of one to six bushels, and to be strewed as evenly as possible on the plants, in warm weather in the spring months, when the plants are putting forth the broad leaves; and, if possible, soon after rain has fallen. If the roots of clover be increased by the application, the succeeding crop of wheat will be much advanced. The effects on turnips, and on culmiferous plants, are even more doubtful than on grasses, and no result has happened to warrant the conclusion that the effects would be quicker, greater, or more permanent, if the substance was ploughed into the land by drilling with the seed or by broadcast, and though the land be rank and fresh with animal and vegetable matters. Gypsum quickly combines with water, and forms a paste; and to the circumstance of this paste retaining moisture, and preventing the scorching effects of heat and drought by sheltering the plants, the effects of the application have been attributed. To the attraction and retention of moisture, farmers continue to ascribe the benefits that have been derived, though the opinion is contrary to that of science deduced from the chemical qualities of the substance.

The futile idea that the failure of gypsum as a manure is owing to the small quantity of it that is found in some soils, and that it should be applied to ensure success on lands that do not contain it, has already been noticed; and equally futile is the notion that lands said to be tired of growing clover may be made to produce that plant by applications of gypsum, because the ashes of clover contain that substance. The failures of clover crops, or, generally speaking, of any crops on lands not constitutionally opposed to their growth, arises, not

from a want in the soil of one per cent. of gypsum, or of any similar substance in that quantity, but from an injudicious and impoverishing system of managing the land, which excludes ample manuring at proper intervals, and the well-timed recurrence of the plants sown for crops. Lands tired of growing clovers, or wholly rejecting plants that are not physically inappropriate, will not be found where *farming* is practised—for the cropping of lands and *farming* are widely different terms. A continuation of the land in pasture has been found to ensure several crops of the clovers—a result that never could have been derived from any scientific inquiry.

Agriculturists of experience agree in recommending the use of gypsum on dry rather than on wet lands, on sands, dry chalk, and loams, and even on clays, if well drained, and in dry seasons. But if a substance on which the farmer bestows money and labour in preparing and applying it as a manure be liable to have its effects dispelled by a shower of rain, or by a gust of wind, as is very generally acknowledged to happen in the case of gypsum, it has little chance ever to attain a very prominent position in the number of useful and trusted fertilizers. But as the statements for and against the utility of gypsum as a manure are pretty well balanced, the just and reasonable conclusion is, that in places where the fossil abounds, or to which it can be carried at a moderate expense, or where the farmer is in want of materials that are cheaper, and on which he can place more dependence, very considerable benefits may be derived from a judicious use of it.

Mud.—Mud is the sediment, slime, or uliginous matter found in the bottom of ponds, and of all stagnant waters, and is mostly composed of the earthy particles collected by the water from the neighbouring grounds, and deposited in the hollow places where the waters congregate, and lose the power of further progress. The composition of mud will, in every case, be regulated by the nature of the substances that come within the reach of the waters that flow into the pond or hollow place. In the vicinity of woods, much vegetable matter will be found in mud, near farmyards both dung and urine will be found in the ponds; while in open situations, earths and sands will be the chief materials, washed down and carried along by the rains and currents, and leaves of trees and various collections of animal and vegetable matters will be added in many situations. Mud in any form is an excellent manure; the particles are in a minute state of reduction, and are in the fittest possible form for being blended with the soil, becoming a part of it, and adding to its fertility. Mud, in a fresh state, may be laid on fallows, or on grass lands, and much benefit will

be derived in all cases; but some prefer to dry it, and mix it with dung and effete lime, and thus procure the benefits supposed to arise from mixing and reducing different substances into one mass. The dry state of mud is most favourable for equal distribution.

"Sea-mud" is found at the mouths of rivers that admit the tide, and is usually deposited in bays and corners, where the easy motion of the water allows it to settle.

It has been found very beneficial on mossy grounds, and has been applied, unprepared, to fallows and grass lands with various effects. The quality is very various, the carriage heavy, and the effects rather uncertain.

Soot.—Soot is condensed or embodied smoke, a clammy, earthy, volatile matter arising with the smoke, by the action of fire on combustible bodies, and condensed on the sides of the chimney. It yields by distillation volatile alkali and an empyreumatic oil, and a quantity of fixed matter, remaining at the bottom of the vessel. It contains a black carbonaceous matter, with carbonated ammonia, and gives a strong pungent smell, with the touch of quick lime; it affords a brown extractive matter of a bitter taste, some ammoniacal salts, and an empyreumatic oil; but its great basis is charcoal, capable of being rendered soluble by the action of oxygen and water. A slight portion of fibrous matter is volatilized by the fire, and again occurs in the soot.

Soot has been long used as a top-dressing on grass lands, on all culmiferous crops, and also on turnips, just after brairding, as a preventive of the fly. The general season of application is in the months of March and April, and, if possible, during calm, mild, and showery weather. It has also been successfully used in autumn. The average quantity used on an acre may be stated at forty to fifty bushels. Soot, almost in every case, produces good effects, on weak clovers and on sickly wheats it will work a very great change in restoring the vigorous green healthy colour, and in causing much tillering from the roots. It also answers well on vetches. Soot is often used in a mixed state with water.

A watery infusion of soot is eminently artiseptic, according to M. Braconnot, and may be used for preserving animal matters from decomposition. Its constituents are, by analysis of the above chemist:—

1. Ulmin, like that produced artificially from sawdust and potash,	30·20
2. Animalized matter soluble in water, but insoluble in alcohol,	20·00
3. Carbonate of lime, with traces of carbonate of magnesia.	14·66
4. Water,	12·5
5. Acetate of lime,	5·65
6. Sulphate of lime,	5·00

7. Acetate of potash,	4·10	11. Acetate of magnesia,	0·53
8. Carbonaceous matter dissoluble in alkalies,	3·85	12. Peculiar bitter principle, (asboline),	0·50
9. Ferruginous phosphate of lime,	1·50	13. Chloride of potassium,	0·36
10. Silica,	0·95	14. Acetate of ammonia,	0·20
		15. Acetate of iron—a trace	—

Few substances are more certain in effect as a manure than soot; but, as may be readily concluded from its nature and composition, it lasts only for one season.

Bleachers' Ashes.—Bleachers' ashes and soap are in some measure similar, being composed of the undissolved parts of potash, kelp, and barilla, and the latter are chiefly formed of lime used by the soapmakers to neutralize the alkaline salts, or deprive them of their fixed air. Soap leys are alkaline salts and oil from a solution of soap in water, and should be carefully preserved to enrich earthy composts. The Chinese preserve even the suds of the barber. The caustic quality of all such substances is removed by mixing them in large proportions of earth, and they may then be applied on pastures and meadows, and on arable land, and harrowed in with the seed.

Soap Boilers' Waste.—Soap boilers' waste has been much recommended, chiefly from the saline matter it contains, which is very minute, and its quality as a manure depends on which of the alkalies the soap boilers may use, as kelp and barilla are more effectual than common potash. It is said to contain:—

Carbonate of Lime	57	Alumina,	6
Magnesia,	11	Silica,	21

This substance operates well as a manure, and the safer mode of application recommends the mixing it with four times the bulk of good earth, and to apply the compost to grass lands and young crops. The caustic quality requires correction by exposure, and mixing with cool materials.

Coal Ashes.—Coal ashes have been long known as a valuable article in improving all stiff tenacious soils, in opening the texture, and breaking the adhesiveness, and in a pulverized state, as an excellent top-dressing for young grasses. They are chiefly composed of siliceous and aluminous earths; they also contain carbon and hydrogen, some iron, and much carbonic acid gas. They are used for top-dressing clovers and all young grasses, at a rate varying from fifty to two hundred bushels per acre, and the effects are generally very great and certain. The calcareous matter they contain imparts the warming and sweetening quality that is attached to all residual substances

from combustion, and hence the use is much recommended on sour grass lands, and on soils that require the effects now mentioned.

Coal dust, or the pulverised particles of coal during the operations at the pits, has been found useful in some cases on stiff lands; but the benefit must have arisen wholly from the operation of the substance as an earthy ingredient, as the material used contains in itself none of the elements of vegetation, nor does it possess the power of producing them by any stimulating or reciprocal action. Black peat dust is a substance of very similar effect, and has been supposed to attract humidity, from containing iron and much hydrogen gas. In the west of Scotland, and probably elsewhere, a mixture of coal ashes, night soil, and other matters, is applied in considerable quantities to raise turnip and bean crops, and for dressing fallow lands.

COAL TAR.—Coal tar, or gas tar, is got from the coals that are manufactured for gas, contains ammoniacal substances that are reckoned very favourable to vegetation; but it is much too strong in an unmixed state, and will destroy all vegetation during the first year of the application, and raise strong crops during the succeeding years. Hence it requires much mixing and an extreme diffusion through earths and mild lime that the adhesive clamminess of the tar may be completely destroyed and diffused through the mass. The compost may then be applied to grasses of all descriptions.

SALT.—Common salt is found as a rock in the new red-sandstone formation, and alternates with lime, clay, and sandstone—colour usually yellow, grey, or nearly white—occurs massive and dentiform, and also in straight and curved fibrous concretions in beds, varying from four to a hundred and thirty feet in thickness. When laid on burning coals, or exposed to the action of the blowpipe, it decrepitates briskly. Rock salt from Cheshire contains, in 1000 parts:—

Chloride of sodium	983·25	Chloride of magnesium	0·19
Sulphate of lime	6·50	Chloride of calcium	0·06
Insoluble matter	10·00		

60 parts of common salt contain:—

Sodium	24	Chloride	36

The colour of salt arises from the presence of animalcules, which may be seen by placing the salt with a little water on the object-glass of a microscope, when the salt dissolves and leaves the animalcules remaining.

The difference in the quality of salt from rock, or from sea-water by evaporation, which generally contains about three per cent. of that

substance, will be very little, arising chiefly from the modes of preparing it. Salt has a strong attraction for moisture: at a temperature of 60°, 100 parts of water dissolve 37 parts of salt, which requires about three times its weight of water to dissolve it, and rather less of boiling water; it is not affected by dry air, is very attractive of moisture, and, magnesia quickly renders it deliquescent.

Salt may be applied as a manure, in a pure state, or mixed with earths in compost, and with moss and lime. About sixteen bushels of pure salt may be laid on meadows and pastures, and composts at the rate of twenty loads an acre. On culmiferous crops it may be applied after the seed has been sown and harrowed; for green crops it may be mixed with the soil before the seeds are sown. The attraction of moisture has formed a chief recommendation of salt, but experience justifies the conclusion that the benefits will be best conveyed to the land in composts of earths and dungs. It has proved very beneficial, when sown on clay fallows during the process of working the land, for the purpose of reducing the viscous and tenacious adherence of the soil. Salt is found in every animal and vegetable manure, and in many rocks, and consequently must exist in soils that are formed from them.

NITRE.—Nitre, or saltpetre, is called the nitrate of potass in chemistry, or the fixed vegetable alkali in combination with the nitric acid, one of the most powerful acids that is known, and constituted of nitrogen and oxygen in the proportions to each other of 40 oxygen and 14 of nitrogen. Saltpetre is found in thin crusts on the surface of the soil, and sometimes covering rocks, as those of limestone and chalk; it is formed wherever animal matters are decomposed, and on grounds where excrements are dropped, on walls of houses, in drains, and where putrid vapours abound. The crusted and efflorescent formations contain:—

Nitrate of potass	42·55	Carbonate of lime	30·40
Sulphate of lime	25·45	Chloride of potassium	0·20
Loss	1·40		

Potash is got by lixiviating the ashes of plants, and is now ascertained to be the oxide of potassium, one of the newly-discovered kaligenous metals, and consists of:—

Potassium	86	or	83·371
Oxygen	14	or	16·629

Nitre is applied as a manure in a pure state, as a top-dressing on various crops. It must be bruised to a powder, and sown by hand at the rate of from one to two cwt. per acre. It very much resembles

salt, and the conclusions respecting it are equally vague and uncertain. It has been asserted that on dry soils and in dry seasons, nitre has done harm, and it may be remarked, that the climate seems to have much effect on the action of saline manures. On clay lands, and on cool loams, the results have generally been favourable.

The nitrate of soda consists of the fossil alkali or soda in combination with the nitric acid, and contains :—

Acid	54	Base	32

It is found in the East Indies and in Peru, whence our chief supplies are derived. It is a very soluble substance, and has been thought to equal saltpetre in promoting vegetation. It is applied as nitre, by sowing on the land, before or after the crops are sown, or on brairded culmiferous crops, or on grass lands, or by being mixed in composts.

CHAPTER IV.

PARING AND BURNING.

THE method of paring the surface of rough lands that are overgrown with useless vegetation, and of reducing the parings to ashes by the action of fire, has been practised for a long time past, as it seems to have been very early ascertained that all the vegetable and many other substances that undergo the action of fire, are converted into elements that are highly conducive to the growth of plants. Our earliest writers mention the practice, and they all concur in allowing the very beneficial effects which followed that mode of improving land. The operation is best performed by men provided with spades made for the purpose.

The shaft or handle is of wood, with a considerable curve upwards, and is about seven feet in length : at the upper end a hilt is placed across, about two feet long, by which the man guides the thrusts of the implement. The flat part, or the share, is somewhat more than a foot broad at its insertion into the handle ; the coulter is turned to stand quite erect, and cuts the edge of the turf. The thighs of the workman are protected by wooden flats suspended by straps from his waist ; the implement is moved along by repeated forward thrusts of the man's power, and the turf is thrown on the back by a sudden wrench of the tool to the left side.

Ploughs have been constructed for the purpose of paring lands

having a rough surface, but in most cases have been found ineffectual. Handwork affords the best opportunities of paring the surface, so that no part escapes, and also of working to any required depth. The proper operation of a plough supposes a surface, at least moderately level; but most lands that are subjected to the process of paring and burning are rugged and uneven, and consequently require the nicety of handwork to go into the inequalities, that no herbage be left uncut, and no land remain unpared.

The operation of paring may go on during fair weather in winter, and the turfs, cut about one foot in breadth and two in length, being dried in the spring months, may be placed upright in two's or four's together, to be further dried and prepared for burning. When this latter purpose has been effected, the turfs are laid into conical heaps of three or four feet in height, and fire is applied. The burning is much promoted, if furze or faggot-wood be at hand, or if the land be rich in rough vegetation to encourage the combustion. Extreme calcination is recommended to be avoided, as violent heats may dissipate the vegetable matters, and reduce the earthy materials to slags or scoriæ: a close smothering fire is preferable, which reduces the vegetable part to carbonaceous matter, and torrefies the earthy ingredients. Much attention is required in the process of burning, and circumstances very often hinder the wished-for result.

After the fires are extinguished, the heaps of ashes must be spread regularly over the ground, and allowed time to cool before the land is ploughed, or any seeds sown. The land is ploughed with a thin furrow, in order not to cover the ashes too deeply; and, after being harrowed, till a fine tilth be obtained, the seeds of turnips or cole are sown by hand in the broadcast manner, and covered by a light harrowing and rolling. If the land be of a sandy, or a very loamy nature, it is often ploughed deeply, and fallowed, drilled, and the seed sown at wide intervals. But when the soil is clayey, or stiff, the former mode must be adopted.

Ashes are a very powerful fertilizer, as they contain the essential substances. 200 grains from a chalk soil in Kent gave—

Carbonate of lime	80	Insoluble earthy matter	82
Gypsum	11	Saline matter, principally sulphate of potass and muriate of magnesia, and a little potash	3
Charcoal	9		
Oxide of iron	15		

The insoluble matter would be aluminous and siliceous earths. Gypsum and the oxide of iron are supposed to produce powerful effects on soils which contain an excess of carbonate of lime.

100 parts of ashes from another soil gave :—

Charcoal	6
Common salt and sulphate of potash	3
Oxide of iron	9

100 parts of ashes from a stiff clay soil gave .—

Charcoal	8
Saline matter, chiefly common salt, with a little potash	2
Oxide of iron	7
Carbonate of lime	2

These results would have been more satisfactory, if the soil had been analyzed previous to burning, that the change effected o the constituents might have appeared. Some of the above ingredients are very active substances, but the quantity is small. The ashes are supposed to imbibe carbonic acid, and are reckoned to last for many years, by absorbing in winter the principles they lose during summer. But the formation of charcoal may be reckoned the chief benefit, and some have added to it the oxygenation of the clay by the heat emitted, and also the mechanical effect of the fire in dividing and attenuating the harshness of the soil; but as the process is wholly above-ground, and of short duration, and the under soil is unmoved, much effect may not be produced in that way. It has ever been observed, that vegetation is very luxuriant on the places where the heaps have been burnt, and even where no ashes have been allowed to remain on the ground. There the cause of fertility must be the fire, and the best ashes that could be found have been carried and spread on pared ground where no ashes had been burnt, and produced effects very much inferior to the places where the burning had been performed, and the ashes subsequently spread. The ancients knew well the very powerful action of fire in fertilizing the ground, and the oldest writers mention the practice of applying fire to the land in some way for the purpose of increasing the produce of the earth. There is a cause or agent in burning, and a very powerful one, "which evades the retort of the chemist, and the rationale of the theorist." The effects being certain and undisputed, it only remains for the cultivator to take advantage of the method in the best known way. The average expense of both processes, paring and burning, may be stated at from thirty to fifty shillings an acre.

THE END.

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